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A MIXED METHODS STUDY EXPLORING THE RELATIONSHIP OF COGNITIVE
AND MOTIVATIONAL FACTORS TO SONOGRAPHY STUDENT
PERFORMANCE

by

Renee B. Hathaway

A DISSERTATION

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Under the Supervision of Professor Roger H. Bruning

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AND MOTIVATIONAL FACTORS TO SONOGRAPHY STUDENT
PERFORMANCE

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University of Nebraska, 2018

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The purpose of this mixed methods study was to examine relationships between sonography students' levels of self-regulation and self-efficacy and their performance in a 16-week introductory vascular sonography skills laboratory course. Measures for the study were designed to yield qualitative and quantitative data related to student goals, strategies, and course performance, and were generated by both students and faculty. Qualitative data from the study included student self-reports of self-regulatory strategies and instructor evaluations of student performance, while quantitative data were provided by instructor and student ratings of performance, student self-efficacy ratings, and student reports on their use of deliberate practice. Results showed that many students learning how to perform sonographic examinations encountered motivational challenges that appeared to be tied both to their self-efficacy and their ability to effectively use self-regulatory activities. The findings of the present study suggest possibilities for improving sonography's curricular models and teaching strategies toward the goal of making sonography instruction more efficient and effective.

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CHAPTER 1

Introduction and Literature Review

The human body is composed of a complex set of systems, which work together with one another to support life. Each system is unique, but dependent upon the other systems in order to maintain its ability to support the bodily functions that stem from it. Many of the body's systems are multifaceted and have several essential roles. As a result, the human body inherently has a high probability for a system to malfunction or fail, resulting in the need for medical consultation. In recent years, one of the primary ways by which medical professionals have been able to identify the human body's medical issues is through the use of medical imaging, specifically sonography.

Sonography is a technology that emits high-frequency sound waves (ultrasound) into the body from the surface of the skin with the aid of a handheld transducer or probe. By using skilled minute hand movements, sonographers produce real-time images and videos of the inner workings of the human body. Other common procedures like physical examination and blood tests are used in conjunction with sonography to diagnose medical issues.

Sonography is a valuable tool that has been increasingly accessible to modern medicine and has been shown to be highly reliable in providing a means for health professionals to diagnose a myriad of life threatening medical conditions (stroke, blood clots, heart defects, and cancer). Sonography allows such medical conditions to be diagnosed in a primarily non-invasive manner. An example of the type of image that is created by a sonographer using an ultrasonic machine is provided in Figure 1, which shows a sonogram displaying the arteries that supply blood flow to the brain, neck, face,

and scalp. The sonogram example shown was solely created by a sonographer as she skillfully guided the transducer over the surface of the skin above the neck vessels, while performing several operations on the ultrasonic machine to create the picture of normal anatomy that appears as the colors red and blue and evaluating it for the presence of pathology.



Figure 1. Example of a typical neck sonogram without disease. Sonogram by
Renee B. Hathaway

Sonographers are highly trained medical personnel. They complete a variety of sonographic examinations on patients with ultrasound, and the medical information they obtain during examinations is unique and specialized for each medical case. This information is relayed to the physician, who will make a final diagnosis and formulate a treatment plan from it. Consequently, sonographers can be viewed as the “eyes and ears” for the physicians who are treating the patients under their care. Physicians rely heavily on sonographers’ abilities and skills to provide them with the correct and pertinent information that will allow them to treat their patients with the best care possible.

Becoming an expert in sonography requires mastering a great deal of knowledge ranging from the areas of anatomy, physiology, and pathology of the human body to, how to operate the ultrasonic equipment and interact with patients. When discussing the considerable amount of knowledge needed for sonography one can think of the knowledge as three main types: *declarative*, *procedural*, and *conditional* (Bruning, Schraw, & Norby, 2011; Shell et al., 2010).

According to Bruning et al. (2011) each of the three knowledge types have distinctive purposes. First, *declarative* knowledge can be defined as “knowing” the facts and detailed information about certain subject matters. The second type of knowledge is *procedural* knowledge, which pertains to “knowing how” to perform the particular steps of a task. The third type of knowledge is conditional knowledge, “knowing when and where” to use the other two types of knowledge.

In relation to sonography, these three knowledge types can be understood in the following manner. Declarative knowledge can be thought of as knowing the information and facts that are used in sonography. Information such as anatomy, physiology, pathology, ultrasound physics, signs and symptoms of disease processes, and medical history and terminology are all needed in sonography. Declarative knowledge is the foundation for understanding how to perform sonography.

Procedural knowledge is what allows the facts and information of declarative knowledge to be put into action. It is the knowledge that is the “know how” for performing all of the essential steps required during sonographic examinations. Procedural knowledge provides individuals the ability to perform the correct order of actions to operate ultrasonic equipment.

The third type of knowledge, on which use of declarative and procedural knowledge hinges, is conditional knowledge. The application for conditional knowledge is situational. Conditional knowledge is accessed when sonographers are presented with information that deviates from the set of order of operations and facts they are currently following and a decision needs to be made about the new information. Conditional knowledge is believed to be applied throughout the sonographic examination process and to be dependent upon the sonographer's level of declarative and procedural knowledge.

To demonstrate using a real-life scenario on how all three categories of knowledge apply to sonography, the following example is provided. A patient presents to a medical facility with stroke-like symptoms (e.g. slurring of speech, weakness on side of the body, etc.). Based on these symptoms the medical judgement most typically warrants a sonographer performing a carotid duplex examination of this patient. In order for the sonographer to perform the carotid duplex examination competently he or she should know that the patient's symptoms are likely related to a cerebrovascular accident or transient ischemic attack (stroke or blood clot in a brain blood vessel) and that the most reasonable examination to confirm the etiology of these symptoms is a carotid duplex examination. The recognition of the patient's symptoms and their connection to performing a carotid duplex examination could all be classified as declarative knowledge that is, "knowing that." Beyond having the appropriate declarative knowledge about the medical condition and sonographic procedures linked to that condition, the sonographer also must know how to perform the steps that are a part of a carotid duplex examination, an example of procedural knowledge. In addition to knowing how to perform the individual parts of the examination, the sonographer will need to know how to adjust the

controls on the ultrasonic machine to attain optimal diagnostic images in a systematic manner, a second example of procedural knowledge. Therefore, a critical element to performing sonographic examinations comes from possessing a considerable amount of procedural knowledge or technical skill.

In order to perform the technical portion of sonographic examinations individuals need a specific set of psychomotor skills as a part of their procedural knowledge (hand-eye coordination, spatial orientation, perception, and manual dexterity) to portray patients' medical conditions adequately (Andrist & Schroedter, 2001; Hathaway, 2007, Society of Medical Sonography, 2006). Through these four psychomotor skills individuals are able to move a handheld device called a transducer over the surface of the skin across the body in a coordinated fashion with one hand, while using the other hand to adjust the technical controls on the machine. As these actions are being performed individuals are also simultaneously viewing the sonographic images that are being displayed on the computer monitor.

Figure 2 shows a sonographer performing a routine sonographic examination. This photograph illustrates the complexity of sonography by showing how the sonographer uses bilateral hand movements to position the transducer and adjust the machine's settings while viewing the computer monitor, while at the same time applying knowledge both about the patient's anatomy and the machine to generate the diagnostic quality image on the computer screen.

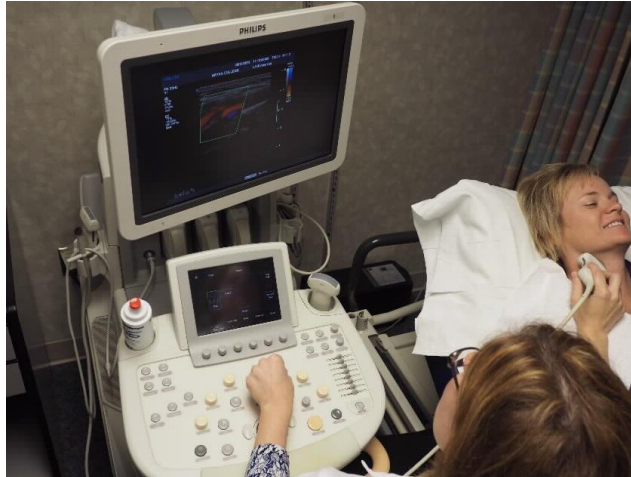


Figure 2. A sonographer performing a routine sonographic examination.

Thus, while both declarative and procedural knowledge are essential for sonographers, at the same time they must have the ability to apply this knowledge in a variety of situations. Specifically, knowing how to perform the examination and operate the machine correctly are examples of procedural knowledge that a sonographer should possess. However, when pathology or other findings are discovered, sonographers must also have the “knowing when and where” or *conditional knowledge*, to obtain additional images or deviate from the protocol and switch quickly to a new protocol that addresses these new findings.

Statement of the Problem

From my experience as a sonographer and educator I can attest to the challenging and involved process of acquiring knowledge and skills to perform the sonographic tasks. Based on sonography’s need for multiple types of knowledge with each dependent upon the others and its significant technical skill requirement, sonography could be described as a complex cognitive-motor task that provides relevant and useful information in the medical profession.

As a result of sonography's complex nature, teaching individuals how to perform sonographic examinations over the years has presented a number of challenges over the years. One of these involves knowledge acquisition when students are confronted with the vast body of relevant knowledge required. A second difficulty faced has been with students who do not self-manage their learning effectively, causing at times unnecessary disorder in the learning process. A third struggle identified with students has involved their lack of motivation to stay engaged and persist in learning the complex skills needed in sonography. For example, less motivated students have the tendency to engage in an insufficient amount of study and practice time. Lastly, a fourth struggle observed for many students during their program of study is lack of confidence issues in their performance of sonographic tasks. Overall, when students experience the challenges of learning sonography, many students exhibit an inability to meet program expectations, resulting in students lagging behind in their academic performance. When students become aware of their insufficiencies in knowledge or skill acquisition some will become disgruntled and blame the instructor for their lack of success. Other students may distance themselves and not be receptive to instructor feedback or to using it constructively. Still others, however, will clearly recognize their need to improve upon their knowledge acquisition and technical skill, leading them to seek assistance from a tutor or the instructor, perform additional practice examinations, or both. Subsequently, such students have been observed engaging in a variety of learning strategies to help them learn sonography and achieve academic success.

As a sonography educator and researcher, I believe gaining an in-depth understanding of the challenges and factors that deter and promote academic success in

sonography is important and necessary and was the impetus for this research study. For this reason, the purpose of this study was to identify the cognitive and motivational challenges students encounter while learning sonography and gain a comprehensive understanding of how learning and performance. Specifically, the present study focused on challenges affecting students' abilities to learn sonography by using a mixed methods research design to explore motivational constructs and their relationship to students' academic performance. The present study's purpose was addressed by discussing the significance of knowledge acquisition and application, followed by motivation's influence drawn from key concepts in psychology. We now turn to a further explanation regarding the challenges sonography students have been observed to face, namely with knowledge acquisition.

In my role as a sonography educator for almost 15 years, I have observed that some students in their first skills laboratory courses experience extreme difficulty with knowing when and where to apply the information as well as how to proceed through a sonographic examination in the correct sequence when unfamiliar circumstances arise. In other words students struggle to attain a sufficient level of conditional knowledge about sonography. Students who experience difficulty with conditional knowledge may have acquired an adequate amount of declarative and procedural knowledge, but not have yet automatized their declarative and procedural knowledge. Lacking *automaticity* of their declarative and procedural knowledge, the students are unable to access their conditional knowledge. Automaticity is a process of achieving through repetition of a specified task the ability to execute the task with little to no effort in the thought process about it (LaBerge & Samuels, 1974; Shiffrin & Schneider, 1977). From the perspective of this

sonography educator, these students seem to have acquired a sufficient amount of declarative and procedural knowledge that allows them to function for a brief time with the sonography learning process. However, when these students attempt to *apply* their declarative and procedural knowledge, which requires them to draw on their conditional knowledge, they begin to experience difficulty and display distress. Consequently, sonography students who struggle with their performance and usage of conditional knowledge fail to put the “whole picture or sonogram” together, figuratively and literally speaking. Students who struggle with conditional knowledge application often perform adequately until situations present themselves that require them to make adjustments or deviate slightly from a standard protocol, resulting in students sometimes failing to complete even the simplest of procedural steps associated with the examination.

Students who lack conditional knowledge or have not automatized their declarative or procedural knowledge also appear to use a less efficient and at times ineffective “trial and error” method to perform sonographic examinations. The use of the “trial and error” technique becomes evident when students are observed in the act of performing sonographic examinations requiring them to make more than one adjustment to the machine’s controls and the transducer position they are holding. All in all, without conditional knowledge, declarative and procedural knowledge may be considered simply as a collection of facts and steps that could not be properly applied in sonography, causing students to experience an array of challenges and preventing them from competently learning sonography (Hathaway, 2007, 2013, 2015).

Some of the difficulties sonography students have been observed experiencing include an inability to obtain an appropriate level of knowledge and automatize it along

with the skills needed to properly operate the ultrasonic equipment. For other students, however, their difficulty is not related so much to knowledge acquisition, but pertains to motivation. Students who experience difficulty with motivation generally appear to have difficulty self-regulating their learning or having an adequate level of confidence to perform the sonographic tasks required of them, and sometimes it is both.

Motivation has been a well-researched variable in numerous fields and domains, and a number of factors found to influence it. Based on the challenges students appear to have with motivation and its posited effect on sonographic skill acquisition, this research study was designed to examine key psychological concepts previously found to have a relationship to motivated performance. The two main psychological concepts that have been identified as significant to this research study, have been widely researched, and shown to affect the more broad term of motivation are *self-regulation* and *self-efficacy*. Schunk and Zimmerman (1997) have been credited with researching in-depth the concept of self-regulation, whereas Bandura (1986) studied self-efficacy. In the present study, both self-regulation and self-efficacy were found to have the potential to influence skill development in sonography as they have been shown to do in other domains. I will now discuss each concept and its applicability in sonography students' academic success.

Self-Regulation

According to Zimmerman (1989) self-regulated students are those who take a self-initiative to participate in actions that are intentional and adaptable to attain personal goals. In turn, self-regulation is posited to have a direct effect on goal achievement (Locke & Latham, 2002) a by-product of self-regulation, and an element of this study. In academic settings, students who self-regulate assist themselves in beginning and

continuing their course work and additional academic related activities (Zimmerman, 1989). In an applied health care education program such as sonography, students are expected to plan and manage their time to attend class/clinical and complete assignments, engage in the necessary amount of practice to learn skills competently, organize instructional content, and use effective learning strategies.

In working with sonography students for the past several years, I have witnessed many students periodically struggle with self-regulation as it pertains to their sonographic skill development. Furthermore, students who struggle with self-regulation in this manner tend to have the most difficulty with it earlier rather than later in their sonographic skills training. I suspect that when students experience difficulty with self-regulation early in their training this is due to their lack of knowledge on how to engage in self-regulatory strategies effectively. More than likely students just have not had the opportunity yet to exercise their engagement with self-regulation in this capacity; therefore do not know how to; but further research is needed to confirm this hypothesis. On the other hand, students who appear to have the greatest academic success have been observed to be more self-regulatory with their skill development. Based on my observations and interactions with these successful students, they seem clearly to have a collection of self-regulatory strategies that they draw upon when they are learning sonography; these observations supported self-regulation as a key element and was included in this research study.

The research on self-regulation for this study was primarily reviewed from the medical and nursing education communities. Major foci for this self-regulation research has been a reflective analysis on the importance of it in medical education, strategies that

promote self-regulation, populations who would use self-regulatory skills, and factors that influence the skill of self-regulation.

A paper on self-regulation and sonography by Butler and Brydges (2013), for instance, reflected on the reasons self-regulation is important for learning to take place in the health professions. Their approach involved a review and close examination of two research articles. The first article they reviewed compared a self-guided curriculum to one that was more faculty driven for teaching novice medical interns in sonography or ultrasonography. The second, compared medical students' learning processes (i.e. self-explanations) with their development of clinical reasoning. Butler and Brydges concluded that clinical learning takes place for novices from supports that are provided within their study environments coupled with learning strategies. They further pointed out that most of the models for self-regulation have focused on how individuals adaptively manage engagement in an activity and the skills needed by trainees to be self-regulated in clinical practice. Furthermore, they argue that the concept of self-regulation should encompass more than what learners do by themselves. Instead, they contend, self-regulated learning can be effectively enacted by combining opportunities for self-regulation with aids that promote how to learn. This point of view was support to research the self-regulatory activities that students completed on a weekly basis that are both self-identified and faculty-provided. Both types were investigated in this research study.

Brydges and Butler (2012) also completed a reflective analysis of medical education research on self-regulation in learning and practice. They identified literature that concentrated on self-regulation or self-directed learning, and drew from multiple

perspectives. The impetus for their reflective analysis on self-regulation was to highlight the necessity of health care professionals and those training for the profession to have self-regulation. Self-regulation is considered to be both essential for health care professionals to engage in and a complex process to learn, which are themes identified repeatedly throughout the health care literature (Brydges & Butler, 2012; Berkhout et al., 2015). This strong emphasis on self-regulation presumably may be attributed to the frequent occurrence of complex situations that arise in this field, which require a higher level of self-functioning to deal with them (Schunk & Zimmerman, 1997). Based on their analysis they proposed that self-regulation is not just a one-dimensional concept influencing learning and practice; instead, it is intertwined among multiple layers of context and a complex construct to explain and warrants further examination particularly in medical education.

Additional research on self-regulation has identified how students are self-regulated in classroom settings (i.e. lecture), but that the practices learned there do not always transfer to the clinical environment, indicating that the applicability of self-regulation instruction and activities are more environment- and skill- specific (Brydges & Butler, 2012). Thus, one goal of the present study was to identify the self-regulatory practices students used and which ones were beneficial to possess in a sonographic skills laboratory course, a course that is different from a lecture-based course and a clinical practicum because of its specific focus on skill acquisition, however, the skills and techniques students learn in the skills laboratory course are more related to the clinical environment. In contrast, the content learned in the lecture-based sonography course is

expected to be connected to and applied in the skills laboratory course and eventually transferred to the clinical setting.

Based on self-regulation's multidimensional nature other research was sought to describe it more completely. For example, research by Berkhout et al. (2015) identified self-regulation as a complex interactive process that is highly interdependent upon the following factors: self-efficacy, goal-setting, and task interest. The aim of Berkhout et al.'s study was to identify factors that either promote or discourage self-regulated learning for medical students in a clinical environment. The results showed students' goals, their perceived opportunity to self-regulate, the degree of autonomy they experienced, and the anticipated outcome that a self-regulated activity would bring were four factors that influenced students' self-regulated learning in the clinical environment. The four factors themselves were affected by personal, contextual, and social attributes. Discussion included the many unique opportunities that the clinical setting holds for self-regulation for individuals to participate in and how they are different from the classroom setting. It was noted that novices do not always know how to navigate the clinical environment in a self-regulated way, and may benefit from assistance in developing self-regulatory skills in the clinical setting. Furthermore, students often describe goals as being important influencing factors that helped them persist in learning. Lastly, how students perceived the importance level of tasks seems to determine whether they would set goals and plan strategies to accomplish those tasks.

Berkhout et al.'s (2015) study gives support to the present research effort by providing insight into the factors that affect self-regulation in both a positive or negative manner. This research study was designed to add to Berkhout et al.'s results by exploring

how providing student feedback with goal-setting might influence their self-regulation in the skills laboratory. Goal setting was identified as a self-regulatory activity. The skills laboratory course was a prerequisite and analogous to the clinical setting. Thus, it was hypothesized that if students were helped to be prepared for the clinical environment because of resources for self-regulation utilized in the skills laboratory, the amount of learning difficulties would decrease. Lastly, providing feedback was anticipated to instill in students self-regulatory knowledge and skills that would assist them in learning how to perform more complex tasks within the clinical setting.

Sandars and Patel (2015) have further discussed the self-regulation challenges that students experience in the clinical environment. Their response to the challenge of decreasing the difficulty associated with self-regulated learning appears in a recommendation to use a trans-theoretical educational model for teaching clinical diagnostic decision making. The model would highlight the importance of learning how to perform diagnostic tasks in a myriad of clinical settings by medical students. One of the key items of the model is promotion of a self-regulatory microanalysis by asking students a series of target questions before, during, and after the performance of a particular task in conjunction with the active participation of engaging in the task.

Similar to Sandars and Patel's (2015) study, the present study was designed to include a comparable self-regulatory microanalysis delivered through a weekly survey to identify self-regulatory activities and the amount of deliberate practice students engaged in each week. The goal here was to determine which self-regulatory activities students were using and the amount of deliberate practice they engaged in while learning how to

perform sonographic examinations in order to examine possible relationships to their academic performance.

Additional research focusing on self-regulated learning strategies, has been conducted by Mullen (2007), who investigated the use of self-regulating learning strategies by students in their second and third trimesters of an accelerated second-degree baccalaureate nursing program. The aim of this descriptive, exploratory study was to examine the presence, extent of, and differences in self-reported regulatory learning strategy of two groups of non-nursing college graduates. The results indicated nursing students who have progressed further into the accelerated nursing program were found to have a higher usage of self-regulatory strategies than the other group of students in their second semester. Students who were in their third trimester were found to be using two resource management strategies--time and study environment and effort regulation. Mullen's conclusion was that self-regulatory strategies do in fact have a significant impact on students' success in an accelerated program. Similar results were found by Duvivier et al. (2011), who showed that students who were further along in their schooling were more apt to self-regulate by using deliberate practice. In my observations as an educator, students who are more advanced in their sonography curriculum tend to engage in more self-regulatory strategies, which appear to assist them in being more successful in their sonography program. Most typically, the self-regulatory strategies I have observed have been closely tied to activities involving additional practice of skills.

Other self-regulation research has explored the impact of self-regulated learning theory on reflective practice in nursing. Kuiper & Pesut (2004), for instance, studied the idea that both cognitive and metacognitive skills support the development of clinical

reasoning skills through the use of self-regulated learning strategies. Their results showed that nursing students' and practicing nurses' cognitive (critical thinking) and metacognitive skills do improve through the use of self-regulated learning strategies, supporting the use of self-regulation theory as a basis for cultivating clinical reasoning skills in the nursing clinical and education environments. Based on Kuiper and Pesut's findings and the present researcher's judgments of sonography's high cognitive demands, investigating self-regulation's influence on sonography skill acquisition was judged to be a potentially fruitful area for additional inquiry.

Further support for the importance of studying self-regulation in sonography comes from Sandars and Cleary (2011), who examined self-regulation theory in medical education. They reported on several empirically supported self-regulation models, highlighting those having a social-cognitive perspective and a cyclical approach to learning—for instance, models based on the works of Bandura beginning in the 1960s and 1970s and Zimmerman (2000). In close alignment with the goals of the present study, Sandars and Cleary have argued for the value of identifying the self-regulatory activities students are engaging in and their effect on student academic performance in sonography.

Sandars and Cleary (2011) focused on three important characteristics of self-regulated learners shared across various theories: goal-directed behavior, use of specific strategies to attain goals, and adaptation of one's actions or strategies to optimize learning. Their view is that a comprehensive theoretical model of self-regulation tied to three important characteristics of self-regulated learners should inform the design of medical education. Their practical tips on how self-regulation theory can be used to

improve academic and clinical performance in medical education specifically include a strong emphasis on feedback. Sandars and Cleary's article on self-regulation and learning skills in medical education has direct application to sonography. Sandars and Cleary also suggested that self-regulation is a critical building block for the persistence necessary to engage in the practice of complex tasks. This was an important consideration based on how complex sonographic tasks are and the significant amount of practice that is required to learn them. Investigating self-regulation's relationship to sonographic skill acquisition, therefore, may be particularly relevant to sonography education. However, self-regulation was only one of two primary factors speculated to have an effect on learning the skills needed in sonography. We now turn to discussing a second main factor self-efficacy that may influence sonographic skill acquisition.

Self-Efficacy

Self-efficacy refers to the self-perceptions persons have about their capabilities to learn or perform tasks in specific domains (Bandura, 1986). Self-efficacy may be equally as important as self-regulation and is thought to be influenced by self-regulation (Zimmerman, 1990, 1998). Locke and Latham (2006) found individuals who are more self-efficacious have a greater tendency to engage in complex tasks and be successful in completing them. Given sonography's required complex skill set, this likely is an important point to consider in the education of sonography students. Therefore, an assumption for this research study was that individuals who possessed higher levels of self-efficacy would show more persistence toward practicing skills to advance their sonographic skills training.

In this researcher's examination of the literature, an abundance of research on self-efficacy was identified with the self-efficacy construct appearing in a multitude of domains and associated with many other important constructs due to its interconnectedness with them. For example, a significant number of research studies provided evidence that self-efficacy beliefs predict academic performance (Schunk & Hanson, 1985; Schunk, Hanson, & Cox, 1987; Pajares & Kranzler, 1995; Siegel, Galassi, & Ware, 1985). Other researchers found students with increased self-efficacy levels will likely work on more difficult tasks, give additional effort, and persist longer when challenges arise (Bandura, 1993, 1997; Pajares, 1996; Schunk, 1991). These studies point toward a positive correlation between self-efficacy and a willingness to engage in important goal-related tasks, suggesting an interdependence between them. Lastly, students who possess a higher level of self-efficacy tend to show more perceived sense of control or choice in their life (autonomy) than those who do not (Vieira & Grantham, 2011). Based on the aforementioned research findings, the goal for this research study was to explore self-efficacy and how it might relate to the engagement in more challenging tasks that appeared to require more effort to learn and complete in the area of sonographic skill acquisition. Due to a wide range of self-efficacy research in other domains and its non-existence in sonography, a selection of research on self-efficacy that primarily relates to complex skill acquisition in college students in comparable applied health care fields to sonography was reviewed for this study.

An example of research found applicable to sonography comes from the field of nursing education. Karabacak, Serbest, Onturk, Aslan, and Olgun (2013) examined the relationship between student nurses' self-efficacy and psychomotor skills competence.

The instrumentation used to collect the data for the study was a student introduction form, 23-item Self-Efficacy Scale (SES), and an intramuscular (IM) injection procedure checklist. The measures were completed by 100% of the nursing students. The results showed that the self-efficacy mean score was high both before and after skills training for the 100 nursing students that were part of the sample, with no significant difference found. However, a different result was found for the psychomotor skills IM injection procedure checklist. The students' mean score on the psychomotor skills IM procedure checklist showed a difference between the first and the second application of the SES with the first application of SES being lower than the second application.

Similar to Karabacak et al.'s research study, the present study assessed self-efficacy while students were engaging in the training of psychomotor skills or developing their procedural knowledge with one major difference. The sonography students for this study were required to learn multiple sonographic skills at one time, instead of the singular learned psychomotor skill reported in Karabacak et al., and self-efficacy levels were assessed throughout the learning process. Therefore, in the present study it was hypothesized that students' self-efficacy levels would fluctuate as they progressed with their psychomotor skills and procedural knowledge development in sonography due to the added difficulty of learning multiple sonographic skills at one time.

In addition to learning a new set of psychomotor skills (procedural knowledge), sonography students are required to develop a high level of cognitive skill (declarative knowledge) for performing sonographic examinations. As a result, the need for developing both psychomotor and cognitive skills simultaneously likely would could

have been challenging and may have led to a negative impact on some students' self-efficacy levels for performing sonographic examinations.

One study that examined self-efficacy and complex skill development was conducted by Aper, Reniers, Koole, Valcke, and Derese (2012). Aper et al. investigated the impact of three consultation training formats on second year master medical students' self-efficacy beliefs and their consultation skills acquisition. In this study, the task of conducting a medical consultation with a patient was judged to constitute a complex skill for medical students because of its compound makeup of both cognitive and motivational components. An initial format involved traditional training with a supervising physician giving feedback, while a second format involved autonomous training with feedback provided from simulated patients and peers. The third format used online training with video fragments and the responding to guiding questions that did not include direct supervision, but did provide immediate standardized feedback. In addition, the feedback for the traditional and autonomous training began with a self-reflection activity. Overall, the types of training differed in their approach to and level of feedback and supervision. The researchers hypothesized that both self-efficacy and the consultation skills would be fostered in each of the three training conditions.

Student self-efficacy was assessed using a nine-item scale in a pre- and post-test format. Participants responded to each item on the measure on a 10-point Likert scale ranging from 0 "not at all confident" to 10 "completely confident". Results showed a positive effect on self-efficacy levels for the autonomous training with feedback compared to both traditional training and online training formats. The researchers attributed the positive impact on self-efficacy to the alignment of training with principles

of Bandura's (1986) theory of self-efficacy and feedback's affirmative influence. Results for the cognitive component of consultation skill acquisition showed that students who experienced both the traditional and online training formats had a significant increase in the development of the cognitive component for consultation skill competence.

Drawing on these results, the design of training for sonography students in the present study also reflected Bandura's (1986) theory as it relates to self-efficacy beliefs. The primary prediction was that sonography students who experienced training consistent with Bandura's principles, who were provided with regular written and oral instructor/tutor feedback, and who completed self-critiques likely would have overall higher self-efficacy levels about their sonographic skills.

As described by Aper et al. (2012) feedback is a critical factor in medical students' learning of consultation skills by helping them understand their strengths and areas for improvement of their skills. Improving students' abilities to self-regulate should in turn, augment skill acquisition and generate a more positive effect on their self-efficacy and other related qualities, such as optimism and the ability to cope in stressful situations.

Based on the present researcher's observations, almost all students sometime during their education experience some level of distress within their program of study. Whether that stress is directly the result of their inability to fully achieve academic proficiency (unable to master a particular sonographic skill) or from personal/life stressors, these are two examples that have been observed to affect students' academic performance. The stress students exhibit commonly appears to manifest itself in lower

levels of self-efficacy and difficulty with coping as they work on sonographic skill acquisition.

In an example of research that focused on students' self-efficacy and stress, Chemers, Hu, and Garcia (2001) examined the effects of academic self-efficacy and optimism on students' academic performance through a longitudinal study of 1st-year undergraduate university students. The researchers hypothesized that students who have high self-efficacy should view themselves as more able to meet the 1st year demands of the college environment rather than perceiving it as a threat. Likewise, students who are more optimistic will have more positive expectations and better coping styles. Measures of academic self-efficacy, optimism, and challenge-threat evaluation were taken by students immediately after they finished their first semester coursework but before receiving formal evaluation feedback. Additional measures, such as self-rated academic performance and future academic expectations were taken by students at the same time. High school grade point averages (GPAs) also were obtained with permission for each of the participants from their university records.

Results showed that students with higher self-efficacy scores had higher challenge-threat evaluations (i.e. they perceived academic work demand to be more of a challenge than a threat), greater academic expectations, and better academic performance. Highly optimistic students tended to be more efficacious, along with possessing a more positive challenge-threat evaluation and higher academic expectations. Students who had higher high school GPAs had higher self-efficacy and had better academic performance. Highly efficacious students had higher challenge-threat evaluations, which resulted in greater academic expectations and led to better academic performance. Overall, the

results pointed to the level of students' self-efficacy they have during their 1st-year of university life as a powerful predictor of expectations and performance. As an educator, I have observed firsthand that those students who are more optimistic tend to persevere despite the many challenges that learning sonography brings.

For an educator, understanding students' levels of self-efficacy, their levels of academic performance, and how they relate should be highly beneficial. For instance, educators who identify and periodically assessed their students' self-efficacy levels during the learning process may be able to initiate an intervention earlier to assist those students with lower self-efficacy, thereby raising these students' self-efficacy levels before low self-efficacy impacts their academic performance negatively. The present study here evaluated sonography students' self-efficacy levels throughout the sonographic examination learning process.

Additional support for the posited hypotheses on self-efficacy was observed in the research of Diseth (2011), who put forth several hypotheses regarding self-efficacy based on previous research findings and theoretical assumptions about self-efficacy. For example, Diseth hypothesized that preceding achievement will predict self-efficacy and subsequent achievement, but not goal orientation or learning strategies. Self-efficacy will at least partially mediate the effect of preceding achievement on subsequent achievement. Self-efficacy will predict mastery- and performance-approach goal orientations. A mastery approach refers to a focus on the development of competence, reflected by learning and task mastery. A performance-approach can be described as focusing on the demonstration of competence, demonstrated by performing better than others (Kavussanu, Morris, & Ring, 2009). Approach motives (self-efficacy, mastery and

performance-approach) are seen as deep learning strategies while avoidance motives (performance-avoidance goals) tend to predict surface learning strategies.

Diseth's (2011) study was completed with college students who were enrolled in an introductory psychology course at a Norwegian university. Results showed that high school GPA was relatively and strongly correlated with self-efficacy. Deep strategy usage was positively correlated with self-efficacy. The examination grade was positively correlated with high school GPA, deep strategy use, self-efficacy, performance-approach, and mastery, and negatively correlated with surface strategy. Diseth's work indicated prior academic performance (high school GPA) as a source of self-efficacy, but not of performance-approach or mastery goal orientation. Although the results suggested self-efficacy predicted mastery- and performance-approach goal orientation, as hypothesized, the approach motives (self-efficacy, mastery and performance-approach) predicted deep learning strategies.

Overall, Diseth's (2011) research has demonstrated the various relationships that can exist among self-efficacy, learning strategies, and goal-orientations in an introductory psychology course, and was a goal of the present study to show if these various relationships also exist in sonography. The present study was designed with a general expectation of finding similar self-efficacy relationships in sonography with self-efficacy levels, but with the expectation of some differences since Diseth's research was conducted in an introductory psychology course—a course that is significantly different from a sonography skills laboratory-based course.

In an earlier classroom study of strategy usage and self-efficacy, Greene, Miller, Crowson, Duke, and Akey (2004) tested a causal model that explained the influence of

high school students' perceptions of classroom structures (e.g. mastery focus, autonomy support, and non-competitive evaluation) on their self-efficacy, perceptions of the instrumentality of class work in attaining future goals, and their goals in a specific classroom setting. The model focused on how motivational variables, such as self-efficacy, can have an effect on students' cognitive engagement and achievement in the classroom. The researchers found strategy use to have the strongest correlations with self-efficacy, mastery goals, and perceived instrumentality. Self-efficacy scores were most highly correlated with mastery goals, perceived instrumentality, and all the variables measuring classroom perceptions, such as autonomy. Results for perceptions of autonomy support were positively related to grades, strategy use, and adaptive student motivation as measured by mastery goals, self-efficacy, and perceived instrumentality. These results suggest self-efficacy could be positively impacted in the classroom by having students perceive being supported with teaching practices utilizing mastery evaluation and promoting autonomy.

Taken together, prior research from other instructional settings provides support for having sonography students participate in self-reported strategy usage, periodic self-efficacy assessment, and goal-setting based on instructor feedback, all of which were items sonography students participated in as a part of the present study. Although self-efficacy was assumed in the present study to be a primary factor affecting students' ability to learn, an additional self-regulatory activity—practice—was studied for its value in learning sonographic skills. Based on the firsthand experience of the present research, it was assumed that without an appropriate amount of practice, learning the skills and conceptual underpinnings for sonography may be almost impossible for novices.

Through practice, novices are able to develop the techniques and knowledge to properly adjust their hand movements and the machine's settings that will yield high quality images, videos, and sonograms. Learning to coordinate, automatize, and proceduralize the skills needed to perform sonographic tasks can only be effectively accomplished through extensive practice. For the purposes of the present research study, practice was considered an important activity closely tied to self-regulation. We now turn to a discussion on how practice may be influential as a self-regulatory activity by describing a specific type of practice, known as *deliberate practice* that has been shown to be highly effective for skill acquisition in a variety of domains outside of sonography.

Deliberate Practice.

Deliberate practice has been studied as a technique for assisting and augmenting the rate at which students become proficient at skilled tasks. Deliberate practice is a term for learning by structured repetition that meets specific criteria (Ericsson, Krampe, & Tesch-Romer, 1993), and has been identified as a critical component to learning skills in sonography (Hathaway, 2013). The first criterion for deliberate practice is that individuals understand how to perform a task with only a brief period of instruction from a highly-skilled coach, instructor, or trainer for the domain in which skill formation is taking place. Second, when task execution with deliberate practice occurs, individuals should receive immediate feedback about their task performance, along with recommendations on how to improve it. Providing immediate feedback is meant to minimize the chance that the task be practiced incorrectly, thus increasing the likelihood of task accuracy. Third, tasks should be completed numerous times to achieve the most persistent learning. Based on the aforementioned criteria, deliberate practice requires a

considerable amount of time and dedication from students. However, it has been shown to be highly effective for skill development in a multitude of domains, and is specifically relevant to the field of medicine (Ericsson et al. 1993). An ideal example for the field of medicine would be sonography where there is an array of complex skill requirements.

Deliberate practice in medicine.

As previously discussed deliberate practice has been studied in a variety of domains that range from music and chess to athletics and medicine. Some of the interest in deliberate practice in medical education doubtless relates to the critical need to develop high levels of competency within the medical profession. For example, research focused on the effectiveness of deliberate practice for training cardiologists, its role in developing medical expertise, and the acquisition of clinical skills. Ericsson et al. (1993) outlined the theory of deliberate practice processes. Since that time it has been introduced into the medical profession as a means for skill development. Based on its applicability in medicine its potential use in other applied health care fields, such as sonography, may be just as applicable. Due to the complexity of sonography's skill set, the criteria described for deliberate practice may be extremely appropriate as an element of learning to be a skilled sonographer. By following Ericsson et al.'s deliberate practice framework my assumption was students were able to work more effectively towards increasing their skill levels and maintaining them. Students in this study were required to engage in deliberate practice for their sonographic skills training and self-report the amount of practice.

One research study focused on deliberate practice and conducted in medical education explored its role in medical students' preclinical training as they progressed from novice to expert (Duvivier et al., 2011). Duvivier et al. (2011) studied medical

students who were in either their first, second, or third years by having them complete a questionnaire about their study habits related to deliberate practice and its use in cognitive learning. The results indicated students had an inclination to use deliberate practice later as they progressed through the curriculum, but were less likely to engage in it earlier on. In reflecting back on their progress, however, they reported that engaging in deliberate practice helped them with their education as they advanced from year one to year three. Based on Duvivier et al.'s results there is evidence that engaging in deliberate practice may be beneficial for learning. Consequently, for this research study there were different cohorts of students engaging in deliberate practice due to the different years they were admitted, therefore having different sequences for their programs of study. For instance, some students were in their first year of sonographic skills training, whereas others were in their second year. All students, however, were in their first year of vascular sonography skills training creating a heterogeneous pool of participants, at varying levels with their education, similar to the Duvivier et al. study with its variability in the research pool, subsequently, providing a possible opportunity to determine if similar results were replicated.

Other research focused on deliberate practice as a part of a cardiology review course. For instance, Issenberg et al. (2002) found residents who engaged in the review course using deliberate practice principles showed remarkable improvement compared to other medical students who just had customary clinical education. Deliberate practice was found to enhance the skills essential for cardiology by allowing formal refinement and skill improvement, an outcome anticipated for sonography as well.

Additional research on deliberate practice has been focused on its relationship to study-related activities of undergraduate medical students (e.g., Moulaert, Verwijnen, Rikers, & Scherpbier, 2004). The results by Moulaert et al.'s (2004) results showed that self-directed study was the main contributing factor to time spent on study-related activities, and showed positive correlations between deliberate practice and study achievements, with high achieving students using deliberate practice more than low achieving students. Based on Moulaert et al.'s results, similar differences were expected in deliberate practice engagement of high and low achieving students. If the results of the Moulaert et al. study hold true, students who engaged in more deliberate practice should perform at a higher level than those who participated in less deliberate practice. Therefore, the general assumption for this research study was that high achieving students who engage in more deliberate practice will have enhanced sonographic skill acquisition.

Another study of deliberate practice by Kulasegaram, Grierson, & Norman, 2013, focused on the relationship between deliberate practice and innate ability, a topic that has long been a topic of debate in sonographic skills training based on previous research (Hathaway, 2007). The question that has been posed previously with innate ability focused on its required amount to be proficient in sonography. Also, the amount of practice time needed to achieve competency in sonography has been debated.

Kulasegaram et al. (2013) conducted a review which focused on whether it was the amount of deliberate practice individuals engaged in or their innate ability that predicted performance. Kulasegaram et al.'s search found nine studies that tested the influence of deliberate practice or its related factors and working memory in predicting

performance. The results showed that learners' amount of deliberate practice individuals engaged in cannot be the only factor by which expertise is formed. Furthermore, expertise must be obtained through more than deliberate practice alone, such as an individual's innate ability. Therefore, the Kulasegaram et al. study is considered to be support for examining the factors that develop expertise in sonography, such as deliberate practice.

The combination of skills and practice needed in learning sonography is not unique to the fields of healthcare and education. For instance, playing a musical instrument has many commonalities with the combination of both motor and cognitive skills involved in sonography. For example, in order for musicians to produce the notes that are written on a score or that have been committed to memory, they not only need to recall and understand the conceptual framework underlying the music and its specific details, but also to simultaneously perform a task requiring a high level of manual dexterity and hand-eye coordination. If there is a breakdown in either the mental or technical performance of the musician while performing on an instrument, it will result in a sub-par performance. In medical diagnostic imaging, however, a failure in either conceptualization or in procedural performance can result in adverse or even fatal outcomes for a patient. Consequently, sonographers must learn to be attentive and make the necessary adjustments for correct image attainment in an accurate and timely manner while performing sonographic examinations.

Based on the significant degree of cognitive involvement by the sonographer and the use of complex ultrasonic equipment to attain pertinent diagnostic medical information, sonography can be described as a highly technical profession that is also

cognitively demanding (Hagen-Ansert, 2002; Hathaway, 2007). Sonography's high level of complexity, therefore, requires an immense amount of practice and repetition to acquire the complex skill set needed, suggesting the need for students to be highly motivated and goal-oriented. This brings us to the importance of goal-setting and its possible influence as a self-regulatory activity in sonography students, similar to deliberate practice and its influence on other motivational constructs, such as self-efficacy.

Goal-setting.

Goal-setting theory has formed the basis for research in a variety of domains and is connected with other prominent social cognitive theories, such as self-efficacy. However, a majority of the goal-setting research has been conducted in organizational or work-related settings (Locke & Latham, 2002). More recent studies on goal-setting have examined it in association with achievement goal theory by focusing students' goal orientations and how they influence intrinsic motivation and academic performance/success (Harackiewicz, Barron, Tauer, Carter, and Elliot, 2000; Barron & Harackiewicz, 2003) with a trichotomous achievement goal framework. Few studies have focused on students being assigned goals or setting their own goals with feedback. Furthermore, the literature yielded no studies that explored the self-regulatory activities and self-efficacy levels of students as they learn a novel complex cognitive-motor task while setting goals and receiving feedback on them. According to Dishon-Berkovitz (2014), studying goal-setting theory in isolation is a limitation for many of the studies conducted to date. For these reasons, goal-setting under the umbrella of self-regulation was included in the present study to explore its effects. Relevant research that began to

address some of the effects of goal-setting studied this construct in association with self-efficacy and feedback.

Kumar and Jagacinski (2011) assessed students' perceived ability (self-efficacy), achievement goals, performance, and affective reactions with veridical feedback (correct vs. incorrect answers) as they experienced differing levels of task difficulty on cognitive problems in an ego-involving or performance goal context. The researchers predicted individuals who experienced increased difficulty over time would show a greater decline in perceived ability compared with individuals who experienced the same level of difficulty. The results showed perceived ability significantly decreased when task difficulty increased. This decrease in perceived ability and increase in task difficulty transferred to a decline in performance approach goals. When performance approach goals were decreased then an increase in work-avoidance goals became evident.

Although the aforementioned research examined the relationships between self-efficacy, goals, feedback, and performance, this was a potential limitation based on research suggesting that students who are more self-regulated tend to have higher levels of self-efficacy (Locke & Latham, 2002). When more self-efficacious individuals are exposed to difficulty there may be less of an effect on their levels of self-efficacy and less of a decline in performance approach goals versus individuals who are less self-efficacious (Locke & Latham, 2002). Additional limitations to Kumar and Jagacinski's (2011) study may be in the generalizability of results due to its brevity, which consisted of three sessions, each session occurring one week apart. The brief time frame may limit understanding of how self-efficacy may be affected long-term when individuals experience varying task difficulty levels over an extended period of time. This research

study avoided this limitation by measuring students' self-efficacy levels periodically throughout a 16-week semester skills laboratory course, while students experienced cognitive challenges and learned multiple psychomotor skills as they performed complex cognitive-motoric tasks.

Other studies conducted across semester-length college courses have examined changes occurring in students' achievement goals (Senko & Harackiewicz, 2005). Based on analysis of these studies, it became apparent to the present researcher that while students' achievement goals are highly important, definitive research is lacking that explains how students' engagement in self-regulatory activities and self-efficacy are affected in tasks requiring sophisticated cognitive and psychomotor skills. Thus, the present study employed a mixed methods convergent parallel research design (Creswell, 2014) to study cognitive and motivational factors concurrently while novices learned to perform the complex tasks of sonography.

Similar to Senko and Harackiewicz's (2005) research, Dishon-Berkovits (2014) examined goal setting and achievement goal theory in academic performance by studying the influence of external goal setting and internal achievement goals with female students enrolled in an introductory college course at an all-women's college in Israel.

Participants for the study were identified with specific assigned performance or assigned learning goals. Achievement goals had been assessed a few weeks prior to the assigning of performance and learning goals. Approximately half the students in one section of the course wrote down a specific, high yet realistic goal in terms of the grade they wished to earn in the course (distal assigned performance goal). The other half of students wrote down learning processes as goals, for instance, learning new material and knowledge, and

to better understand the theories' associated with the subject matter, categorizing this group as having distal assigned learning goals. The results revealed a significant main effect for learning goals. Students who had learning goals generally had higher academic achievement. The findings showed that encouraging mastery achievement goals along with performance-approach achievement goals resulted in higher academic achievement, supporting a multiple goal perspective.

Based on Dishon-Berkovits's (2014) research it would appear to be important for students to have learning goals; however, the type of goal may not be as important just as long as students have them. As a result, the present research study provided students the opportunity to self-set goals of their own choosing and were not limited to a specific goal type. The belief is that by not specifying a certain goal type, sonography students' goal-setting ability was more authentically assessed to determine the types, number, and specificity of goals students are inclined to write. Therefore, the information acquired on goal-setting for students was used to better understand the overarching motivational construct of self-regulation as it functions as a self-regulatory activity.

Similar to Dishon-Berkovits's (2014) research, Acee, Cho, Kim, and Weinstein (2012) investigated the properties of college students' self-set goals and academic achievement. Students were asked to list 20 goals and then rate each of them for value, expectation of success, and autonomous and controlled motivation. The researchers hypothesized that goal properties would be positively related to students' grade point average (GPA) with the exception of controlled motivation, which would have a negative relationship. Findings showed that goal specificity was positively related to semester GPA and controlled motivation was negatively related to semester GPA. The results

suggested students who list more specific goals at the beginning of a semester will tend to have higher academic achievement at the end of the semester, indicating that goal-setting can influence students' academic success.

Although goal-setting has been shown to be effective in producing academic success, the effects of goal-setting when it is accompanied by deliberate practice and detailed frequent feedback was not apparent in the earlier research. Consequently, students in the present study were required to set weekly goals across the semester, while they received detailed feedback about their sonographic skills and performance as they engaged in deliberate practice and additional self-regulatory activities.

Additional research investigating the effect of students' self-set goals on academic performance was conducted by Bipp, Kleingeld, Van Den Tooren, and Schinkel (2015). Their study examined the goal-performance relationship with core self-evaluations on academic performance. The study used a diary method to explore how self-set grade goals and core self-evaluations influenced the grades students obtained on their exams. The results from the study showed the grade goals students self-set for their exams were positively related to how they performed on those exams. Students performed better on exams for which they set higher grade goals.

In general, students who scored high on core self-evaluations had a tendency to set higher grade goals and perform better on examinations; however, when students scored themselves high on core self-evaluations and had set lower grade goals, they demonstrated lower performance than those who had initially scored lower on core self-evaluations. According to Bipp et al. (2015) students who self-evaluate have more

positive academic achievement outcomes. Based on Bipp et al.'s findings, students in the present study were asked to provide self-evaluations about their skills and performance.

For example, each student on average were required to complete three weekly sonographic examination assignments accompanied by a self-evaluation of their skills and performance on each of them. The self-evaluations involved having students critique their sonographic skill performance and competence on each assignment (i.e. errors, areas of improvement and strength). Although Bipp et al.'s study focused more on cognitive tasks, inclusion of self-evaluations for cognitive-motoric tasks in the present research was expected to produce similar findings.

Although there is considerable research on self-evaluation as it relates to academic success, most studies have not fully explored self-evaluation as a self-regulatory activity and how it affects self-efficacy for performing complex cognitive-motor tasks. Therefore, in the present study, the interactions of self-evaluation with overall self-regulation and self-efficacy were examined.

Additional research was found that focused on goal-setting and paired it with self-evaluation. Zimmerman and Kitsantas (1997) researched the constructs of self-regulation, self-efficacy, and self-evaluation with goal-setting while individuals worked on acquiring a complex motor skill. They studied the effects of goal-setting and self-monitoring during self-regulated practice with a complex motor skill acquisition, dart throwing. Participants of the study were high school girls, many of which did not have dart throwing experience. The participants were divided into one of four types of goal-setting experimental conditions (process goal, outcome goal, transformed-process goal, and shifting process-outcome goal) and one of two types of self-recording (present or

absent). The measures for the study included: dart-throwing skill, self-efficacy scale, self-reactions scale, intrinsic interest scale, and an attribution scale. All participants were given instructions on dart throwing and practice time.

The results revealed that goal-setting was highly predictive of self-efficacy and other variables. In turn, self-efficacy was highly predictive of dart-skill performance, positive self-reactions, and intrinsic interest in engaging in dart throwing. The strongest self-efficacy beliefs, greatest amount of dart skill, the most positive self-reactions, and most intrinsic interest in dart throwing was from participants who were first a part of the process goals group, but then shifted to having outcome goals later in the study. These effects were also observed in participants who attributed their failures to strategy insufficiency. When participants self-recorded, this too enhanced the effects of all forms of goal-setting on dart-skill attainment, self-efficacy beliefs, and self-reactions.

Zimmerman and Kitsantas's (1997) results support goal-setting, self-evaluation, and deliberate practice as important factors to consider when individuals are learning to perform a novel complex motor task. Based on Zimmerman and Kitsanta's results, one of the hypotheses of the present research study was that goal-setting, self-evaluation, and deliberate practice would have positive effects on self-efficacy and performance of a novel complex cognitive-motor task.

Zimmerman and Kitsantas's (1997) findings are significant to this research; however, they do not explain complex tasks that have both cognitive and motor elements to them. Furthermore, the additional research that was found which focused on completing complex tasks was limited and included complex tasks that were solely cognitive in nature. An example of this research is Senko, Durik, Patel, Lovejoy, and

Valentiner (2013) who tested the effects of performance approach and mastery approach goals with a novel mathematics task that was intended to be viewed as a simple or complex task. Participants were assigned goals; and their expectations about the difficulty of the task were manipulated to be either simple or complex. Two hypotheses for this study were tested. The first hypothesis was that performance approach goals would produce superior performance when the task appears challenging and not simple. The second hypothesis took an alternative viewpoint suggesting that the performance approach goal will produce inferior performance when anticipating challenge. The results were in support of hypothesis one. Performance approach goals were associated with increased achievement when participants viewed the task as being more complex. Therefore, based on Senko, et al.'s (2013) findings, interpreting how goal-setting affects sonographic skill performance, perceived complexity may need to be considered as a significant factor when interpreting results. Although Senko et al. obtained results that favored performance approach goals for complex tasks over mastery approach goals, their study focused on a novel complex task that was purely cognitive and does not show if the same outcome could occur with a novel task that is a cognitive and motor skill combination. For this reason, research by Kavussanu, Morris, and Ring (2009) was also examined for its effects of achievement goals on performance with a novel motor task, golf-putting.

Kavussanu et al.'s (2009) participants were college students who were assigned to one of three goal conditions (mastery, performance approach, or performance avoidance). Their results indicated the effects of mastery and performance-approach goals on

performance are similar when learning a novel motor task. This may suggest a multiple-goals approach as being more beneficial to pursue when tasks are more motor in nature.

Neither Kavussau et al. (2009) nor Senko et al. (2013) fully explain how tasks are learned when tasks are novel, complex, and cognitive-motor. Further research may be warranted with how novel complex cognitive-motor tasks are learned, and this was the intention of this research study. Additional research found on goal-setting focused more on the role of goals in college courses (Barron & Harackiewicz, 2003). Barron and Harackiewicz's (2003) research was a continuation of research from earlier research done with a large introductory lecture course. The earlier results showed that mastery goals only positively predicted interest; whereas performance goals positively predicted grades, but not interest (Harackiewicz et al., 2000). In Barron and Harackiewicz's more recent study, the researchers explored the benefits of performance-approach goals and mastery goals in a small advanced seminar. Harackiewicz's advanced seminar environment may be likened to a sonography skills laboratory environment based on the low student-to-faculty ratio and more frequent opportunities for one-to-one interactions.

Barron and Harackiewicz (2003) hypothesized that mastery goals may prove more advantageous in the advanced seminar context and performance goals would be less of a benefit. The study's procedure included collecting measures of students' personally adopted achievement goals for the course. Between two to three weeks before the end of the semester measures of students' self-reported interest in the course and their perceptions of the classroom climate were collected. The results surprisingly showed the same relationship between achievement goals and outcomes that were observed in the introductory classes. Mastery goals still predicted interest and performance-approach

goals were positively linked to end-of-the semester grades and not to interest. When students personally adopted achievement goals, they reported pursuing mastery goals the most, followed by performance-approach goals, and then work-avoidance goals. As for the results from perceived classroom climate measures, students reported that their seminar courses promoted a mastery goal climate.

Overall, Barron and Harackiewicz's (2003) results may be seen as important and should be considered for future research that will be conducted in classroom environments that are smaller in size, such as the case in this research study. Based on Barron and Harackiewicz's results, if students' academic performance from the grades they achieve is the desired outcome then performance-approach goals may be an important goal type to consider and to study to determine if it will have a positive correlation with grade prediction. Goal type is a factor that may need to be further researched and taken into account for future research, but was not examined in depth for this study.

In summary, goal-setting has been well-researched and observed to influence other factors, such as self-regulation, self-efficacy, and feedback's purpose, all of which has been identified by the research as having an effect on an individual's chance of succeeding. In order to more fully understand self-regulation and self-efficacy's relationship and their effects on student performance a more thorough description of feedback's effects is necessary. Therefore, a further purpose of the present study was to describe feedback in conjunction with self-regulation, goal-setting, self-evaluation, and self-efficacy.

Feedback.

A study by Locke and Latham (2002) examined feedback in association with self-efficacy and showed that individuals who have a higher degree of self-efficacy tend to respond to negative feedback in a more positive manner. Additionally, the level of self-efficacy that a person has at the time negative feedback is given can also have an effect on either raising or lowering one's goals (Locke & Latham, 2002). Based on an article by Bandura and Locke (2003), feedback that is goal focused will be more productive in directing students to better achieve goals and sustain a higher level of self-efficacy. For this reason, in this research study, the goals students had set on a weekly basis after instructor feedback was considered as one of the self-regulatory activities students engage in to determine if there is a relationship between self-regulation and students' self-efficacy levels while learning a complex cognitive-motor task.

Additional research found describing feedback's effect on self-efficacy and achievement were limited and primarily focused on children. For example, Schunk (1983) explored the effect of ability and effort attributional feedback given during subtraction competency development on children's perceived self-efficacy and achievement. Providing attributional feedback during competency development was expected to enhance students' ability to solve math problems and increase self-efficacy and skills. It was predicted that providing ability feedback along with effort feedback would increase self-efficacy more than effort feedback alone. Self-efficacy judgements were made by children on an efficacy scale. Immediately following the efficacy measurement, the children engaged in a subtraction skill pre-test. After the subtraction test, children were randomly assigned to one of four treatment groups. The four

treatment conditions included: ability attributional feedback, effort attributional feedback, ability + effort attributional feedback, and no attributional feedback. As a part of the research study, children received training about working through their subtraction skill training packets. After the last training session children were given another scale that had them judge the amount of effort they expended during the training sessions and a subtraction skill post-test. The results demonstrated that providing attributional feedback to children as it is related to competency development can promote quicker problem solving, better self-efficacy, and enhanced skill acquisition. These results can be compared to the results from an earlier research study by Schunk (1982) which found students who had been given attributional feedback about successful problem solving resulted in increased levels of arithmetic skill and self-efficacy compared to those given feedback that indicated the need to work hard or those given no attributional feedback. Schunk's results suggest that the type of feedback is important in the development of skill acquisition and self-efficacy and should be deliberate and specific to each student. For this reason, individualized feedback was provided to students in this study in a manner encouraging more effective skill acquisition and increasing self-efficacy.

Goal focused or attributional feedback has been found to be advantageous for skill development and have a positive effect on self-efficacy (Schunk, 1983). According to Schunk (1982, 1983) feedback is able to elicit a positive response on its own. Based on Schunk's works, this research study explored self-efficacy and what effect feedback had on it.

Schunk and Rice (1993) studied the effects of a reading strategy (fading) with and without feedback on self-efficacy and reading comprehension. The research was

conducted with children who were experiencing difficulty with reading skills and receiving remedial assistance. Children were administered measures that evaluated their self-efficacy, comprehension skill, and self-reported strategy use after being randomly assigned to one of four experimental groups: strategy only, feedback only, strategy plus feedback, no strategy or feedback. The results showed that combining strategy usage and feedback for increased performance strengthened self-efficacy, skill, and self-reported strategy use. Schunk and Rice concluded feedback alone may not be as effective, but combining it with strategy usage for skill acquisition may yield greater positive results. Based on these results, this research study was designed to provide students with feedback on a regular basis about their sonographic skill levels and surveyed the types of self-regulatory strategies students engaged in on a weekly basis.

More recent research on feedback focused on the frequency with which it is given. Bosse, et al. (2015) investigated the influence of high versus low frequency expert feedback when students are learning clinical procedural skill acquisition in its early stages. Their hypothesis was with repetitive practice and more frequent feedback a proficient level of procedural skill could be achieved. Medical students who were in their first or second year of medical training participated in the study. The results showed students who engaged in the early acquisition of procedural skills benefit from receiving more frequent feedback. The results from the Bosse, et al. study are important to this research study because a large portion of learning sonography skills involves the attainment of procedural skills. If students are unable to develop a sufficient amount of procedural skills they most likely will not be competent in sonography. As a result for

the research study, sonography students' procedural skill was assessed frequently (weekly basis) with instructor feedback provided.

Additional studies that focused on feedback with procedural skills investigated if the type of feedback that was delivered to students would have an effect on procedural skill acquisition. Wittler, Hartman, Manthey, Hiestand, and Askew (2016) researched video-augmented verbal feedback for procedural skill acquisition and whether it assisted with more accurate self-assessment by medical interns. The aim of the study was to assess if the type of feedback affected the proficiency level of learning a medical procedure. The effects of focused faculty review and standard verbal-only feedback were compared to the effects of video-augmented verbal feedback with procedural skill acquisition and accuracy of self-assessment of those skills. The results indicated that individuals do benefit from having focused feedback based on faculty review about their skill acquisition. However, there is no added benefit to video-augmented verbal feedback over standard verbal-only feedback. These results were further clarified by indicating that medical interns, who performed well on average, underestimated their performance as compared to their faculty evaluations while weak performers overestimated their performance. The researchers interpreted this to mean that focused faculty review and feedback yields a greater benefit in enhancing skill acquisition and self-assessment accuracy over video-augmented verbal feedback. Wittler, et al.'s findings support the notion that focused faculty feedback on skill performance is important to learning, specifically medical procedures, and should be included by educators as a part of their routine teaching practices. This research study design included a considerable amount focused feedback from the faculty in accordance with goal-setting.

A similar study on video feedback was conducted by Backstein, Agnidis, Sadhu, and MacRae (2005) who investigated the effects of video feedback on the acquisition of a surgical technical skill. The purpose of their study was to assess the benefits of having medical residents view themselves practicing a specific medical procedure while an expert provided them feedback during the taping. After the taping, each resident reviewed their entire videotape up to a maximum of 15 minutes with an expert. The residents had the opportunity to fast-forward and rewind the tape and ask questions of the expert. After reviewing their videotape, residents returned to practicing the medical procedure they just viewed. The review of videotapes occurred once a week over a three week period. The results from quantitative measures concluded there was no significant difference among medical residents' skill level for the procedure being tested who had exposure to the repeated video-taped feedback and those who did not. Although in a follow-up qualitative questionnaire, residents did indicate they appreciated the opportunity to receive immediate feedback and being able to actually view their mistakes instead of only being told about them. They believed watching the videos allowed them to "fine-tune" a basic skill. Backstein et al.'s results indicate there may be a benefit for some research studies to acquire data from not only quantitative measures, but also qualitative measures. For this reason, a mixed methods research design was used to conduct research for this study and acquire data regarding students' sonographic skill performance while exploring the motivational constructs of self-regulation and self-efficacy.

Based on the aforementioned research, the type and frequency feedback is delivered can be influential for skill acquisition. An additional study conducted on

feedback examined how performance feedback type (progress vs. distance) affects college students' self-regulation and task achievement in relation to goal importance when working towards multiple goal attainment (Lee, 2016). Participants for the study were Korean college students who were randomly assigned to one of four experimental conditions of goal importance (high vs. low) by performance feedback type (progress vs. distance). All participants were asked to perform two goal tasks in succession, a focal goal task (the specified task the participant was assigned) and additional goal tasks of varying importance as quickly and accurately as they could in no more than 10 minutes. Performance feedback was offered about goal tasks. The type of feedback was altered by offering either progress or distance feedback. While completing the first task, participants also answered questionnaires about goal-setting, time allocation, task enjoyment and effort investment twice.

The results showed participants who were in the high goal importance groups and received distance feedback set higher goal scores and, therefore, demonstrated more self-regulation than those who received progress feedback. Additional findings indicated the participants of the high importance goal condition dedicated more to the early part of the task than the latter part; the participants of low importance goal condition gave more time toward the latter part. Overall, participants in the high goal importance condition took more time to complete tasks than participants in the low goal importance condition. As a result, individuals were willing to dedicate more time to focal tasks of greater importance when starting them, but decreased the amount of time spent on them based on how they were performing and the remaining time left to complete them. The opposite was true for focal goals of lesser importance. Lee's (2016) research strongly suggests the possibility

of a relationship between the goals students had selected and the feedback they receive. Since the majority of feedback delivered to students in this study could be considered as “progress type” coupled with a “high important goal condition”, Lee’s finding was an important consideration. It was posited that including detailed and frequent instructor feedback to sonography students and having them engage in deliberate practice will positively influence students’ self-efficacy, which in turn, impact their skills’ laboratory performance based on their participation with goal-setting.

In conclusion, the existing applied research on the constructs of self-regulation and self-efficacy was found to be instructive, as was the current research on self-regulation, but was judged not to fully address how these variables apply to a specialized medical field such as sonography. As described in detail in the introduction, sonography requires high levels of both knowledge and skill in order to perform competently as a sonographer. As a result, learning how to perform sonographic examinations is not simple. Conducting these examinations places high levels of demand on a sonographer’s cognitive resources, including their ability to process information rapidly and accurately. For this reason, most sonography laboratory course’s curricula have been systematically designed to address issues of high cognitive load by using a *scaffolding* approach to teaching sonography. Therefore, research focused on cognitive load issues and scaffolding was added as a final section of this literature review.

Cognitive load theory/scaffolding.

Due to the complexity of learning the task of sonography, educational methods in this field need to address cognitive load effects on learning new and complex tasks. One way of addressing cognitive load may be to implement a scaffolding approach with the

inclusion of self-reflection and goal-setting by the student, as well as routinely administered instructor feedback on students' skill and goal attainment, all of which must coincide with extensive practice throughout the educational process. When these techniques are applied in this grouping this may be most effective in learning sonography based on previous research (Zimmerman and Kitsantas, 1997; Locke and Latham, 2002).

Complex information in most cases surpasses the working memory's load capacity — something to be mindful of when further discussing cognitive load. Researchers should be aware of the potential to utilize techniques that circumvent working memory's limited processing capability. Subsequently, learning complex information and skills carries with it a heavier working load based on the high number of interacting elements associated with complex learning, limiting working memory's ability to process the knowledge. Therefore, a high element interactivity is predictive of exceeding working memory's capacity to process these individual elements simultaneously. It is hypothesized that being able to process several elements in one setting may need to be a stated requirement to learn complex material (Clark et al., 2006).

Having to process multiple elements at one time could be viewed as a barrier to acquire new information and may be an item to address when learning complex skills. In turn, learning how to perform complex skills can be understood as having a high intrinsic cognitive load and could be considered a barrier to preventing individuals from learning them. Furthermore, complex skills would likely be inherently associated with a higher intrinsic cognitive load based on the absolute limit of intrinsic cognitive load. In designing sonography education, intrinsic cognitive load is an important factor to consider when individuals are learning complex skills.

Cognitive load theory encompasses three types of cognitive load: intrinsic, extraneous, and germane cognitive load (Paas, Tuovinen, Tabbers, Pascal, & Van Gerven, 2003). Each type of cognitive load is unique in its effects and how information is conveyed and learned.

Sweller (2010) describes intrinsic cognitive load as “...concerned with the natural complexity of information that must be understood and material to be learned” (p.124). The amount of intrinsic cognitive load is not based on who or how it is presented, but solely on the properties of complexity and cannot be isolated from other extrinsic factors. Intrinsic cognitive load is also described as occurring based on the level of complexity that information possesses—a point to be cognizant of when individuals are learning to complete complex motor tasks while simultaneously keeping in mind complex information.

Clark et al. (2006) has described material that is complex in nature as having several elements that interact with each other simultaneously and must do so in order to understand the material. It is theorized that the processing of information in the cognitive information processing system is accomplished in working memory (Baddley, 1992). However, working memory has its own set of restrictions attached to it, such as how many elements of information can be processed at a given time, which was originally theorized as seven plus or minus two items (Miller, 1956), and later revised to approximately four pieces plus or minus one by Cowan (2001).

Extraneous cognitive load is defined as the demand imposed on the working memory that uses mental capacity, but does not contribute to learning (Clark et al., 2006, p. 346). Extraneous cognitive load is affected by outside factors, for example

instructional procedures that are not conducive to learning and or that create a distraction to working memory's ability to process information (Sweller, 2010). According to Clark et al. (2006) extraneous cognitive load is changeable and should be minimized to help with the learning process, especially working with material that carries an already high intrinsic cognitive load, for example in learning complex skills. Like intrinsic cognitive load, extraneous cognitive load may also need to be considered in the acquisition of complex skills due to the opposing effects it could potentially have on learning, if the instructional methods used to teach them are not designed to decrease extraneous cognitive load.

Under the umbrella of cognitive load theory, a third type of cognitive load- *germane cognitive load* has been proposed (Clark et al., 2006). Clark et al. (2006) describes germane cognitive load as a load that imposes stress on the working memory, but does so in a manner that is conducive to learning by building mental models from learning experiences which are more robust and test working memory's load.

Based on how intrinsic cognitive load was originally described as unchangeable, this causes a discrepancy between high intrinsic cognitive load material and working memory's load capacity when learning complex skills. So how do individuals learn complex skills? Pollock, Chandler, and Sweller (2002) noted this dilemma with intrinsic cognitive load's original definition and hypothesized that in order for individuals to have the ability to learn complex skills, a reduction in intrinsic cognitive load takes place somewhere in the learning process. Although other cognitive load researchers do not hold the belief that intrinsic cognitive load can be reduced (Plass et al., 2010). The belief that intrinsic cognitive load can be reduced, however, does come with a possible

disadvantage and that is individuals cannot simultaneously maintain a full understanding of the material being conveyed to them. An end result to this perceived deficiency was the modification of the theory to state there is a reduction in intrinsic cognitive load that takes place. As a result, an additional definition of intrinsic load has emerged that defines “intrinsic cognitive load not in terms of element interactivity, but in terms of the amount of information that has to be extracted from the information source with respect to the learning goal” (Plass et al., 2010; p.186). This definition may be more fitting when learning complex skills.

Sweller (2010) states that a primary concern of cognitive load has been with identifying practices that reduce extraneous cognitive load. Based on the previously introduced information regarding intrinsic cognitive load it may be equally advantageous to focus on identifying methods by which intrinsic cognitive load could be decreased. Clark et al. (2006), among others, have attempted to do just that by describing a number of techniques that can be used to decrease not only extraneous cognitive load, but intrinsic cognitive load. Although there are numerous techniques indicated by Clark et al. to reduce extraneous and intrinsic cognitive loads, the technique known as “scaffolding” will be discussed to explain how its methodology can be utilized in the instruction of complex sonographic skills that the participants learned throughout this research study.

Scaffolding is viewed as being a viable technique for teaching complex skills because of its tendency to decrease intrinsic cognitive load through performance support and fading (van Merriënboer, Kirschner, & Kester, 2003). Scaffolding, also referred to as “assisted learning” (Wlodkowski, 2008) has been a researched and recommended theory

to explain a methodology by which intrinsic cognitive load could be procedurally reduced to compensate for working memory's limited load capacity to process separate elements in one setting.

A term associated with scaffolding is *zone of proximal development (ZPD)*. ZPD refers to the amount of assistance individuals need in learning certain tasks (Sternber & Ben-Zeev, 2010; Wlodowski, 2008). Individuals who are in the lower portion of the initial ZPD zones need more assistance to facilitate the completion of tasks. On the opposite end of the ZPD spectrum individuals who are able to perform a task independently are in a higher level of the ZPD zones (Wlodowski, 2008).

Wlodowski (2008) provides examples with descriptions for some of the assisted-learning methods that can be used to scaffold more complex information. Methods include: modeling, thinking out loud, anticipating difficulties, providing prompts and cues, using dialogue and discussion, regulating difficulty, using reciprocal teaching and practice, and providing a checklist (p. 184-186). Other researchers, such as, van Merriënboer et al. (2003) have also discussed approaches for scaffolding, his approaches include decreasing intrinsic cognitive load and learning tasks that lessen the amount of extraneous cognitive load. These approaches are identified in terms of part-task and whole-task approaches.

The part-task approach includes partitioning the task as a whole into individual steps with different objectives for each, which are then reassembled to accomplish performing the whole task successfully. The part-task approach has been shown to be effective in decreasing cognitive load, but has been deemed unsuitable for learning complex tasks. On the other hand, whole-task approaches have individuals performing

the whole task from the beginning, but simplifying as many aspects of the task as possible. Due to the ineffectiveness seen in earlier research studies with the part-task approach, the whole-task approach has been favored for learning complex skills (van Merriënboer et al., 2003).

After reviewing van Merriënboer et al.'s (2003) work on part-task and whole-task approaches and analyzing the benefits and challenges that each bring, it was most appropriate to teach sonography students for the research in this study with a part-task approach for each new type of sonographic examination they learn and transition to a whole-task approach. The belief was that starting with a part-task approach would help decrease the intrinsic load while learning complex tasks. Then transitioning to a whole-task approach once students have learned to automatize many of the processes associated with psychomotor and cognitive functions of sonographic skill performance would allow them to complete the tasks in their entirety and gain the benefits that would come from a whole-task approach.

An additional approach found to have relevance to the issue of how complex learning occurs is by van Merriënboer (1997). Van Merriënboer is credited with developing a four-component instructional design model (4C/ID). The model's methodology describes how learning tasks for complex environments are systematized in a simple-to-complex order of task levels that have progressively decreasing amounts of support for each level. Students who participated in this research study were educated in sonographic skills with van Merriënboer's 4C/ID model in conjunction with his other two approaches as described above.

Based on sonography's divergent skill set which consists of both cognitive and psychomotor skills, learning to perform sonographic examinations could be considered a complex task. For this reason, cognitive load theory's framework and its associated principles were implemented in the curriculum of this study.

In summary, the literature on sonography and in distantly related medical fields appears to be limited and lacking specific research on the motivational constructs of self-regulation and self-efficacy. Research that has been conducted in sonography has focused more on the acquisition of cognitive and psychomotor skills; specifically investigating how the educational processes and methods support them (Hathaway, 2013; 2015). While performing psychomotor and cognitive skill research, Hathaway (2013; 2015) identified several themes regarding how students learn sonography. The themes pointed towards factors that appear to be associated with students' motivation. Based on these outcomes, there is a need to advance the previous research and extend it to studying the motivational constructs that may influence learning sonography. To date, there is no known research study that has investigated the effects of the combined self-regulatory factors of deliberate practice, focused feedback, goal-setting with inclusion of self-evaluation, in conjunction with self-efficacy as individuals learn a novel complex cognitive-motor task. This research study intended to explore the relationship among the motivational constructs of self-regulation and self-efficacy and their impact on learning sonographic skills. Sonographers, sonography educators/preceptors, academic development directors of applied health care education programs, and educators in similar applied health care fields may find this study useful to better understand how

individuals are motivated to learn complex skills involving a high-level of cognitive processing with combined psychomotor skills.

Purpose Statement

The purpose of this mixed methods study was to identify the cognitive and motivational challenges sonography students encountered while learning sonography and gain an in-depth understanding of how they affected students' abilities to learn sonography by exploring the motivational constructs of self-regulation (Schunk & Zimmerman, 1997) and self-efficacy (Bandura, 1986) and their relationship to students' academic performance.

The following self-regulatory activities students engaged in were surveyed: completing assigned and additional *readings*, performing required and/or voluntary *scanning*, obtaining tutor and/or instructor *assistance*, viewing *example videos/images*, the amount of practice and study time expended towards vascular sonography, the self-set goals based on instructor feedback, and other activities students self-reported. A convergent parallel mixed methods design was used, in which qualitative and quantitative data were collected in parallel, analyzed separately, and then merged (Creswell and Plano Clark, 2011). In this study, qualitative data was the primary form of data collected. Qualitative data, such as open-ended and close-ended questions, evaluations of participants' scanning performance, and the primary investigator's observations and interactions with participants were used. These qualitative measures were used to explain the reasons for why students engaged in the type and number of self-regulatory activities that they did, if they believed the amount of practice and study time was insufficient and why, their self-set weekly goals, and a progress report on previously set goals to learn

complex sonographic skills. Qualitative data provided an in-depth understanding as to how the motivational constructs of self-regulation and self-efficacy influenced academic performance in a semester-long skills laboratory course. Quantitative data was in the form of weekly surveys, self-efficacy scales, and evaluations of participant scanning performance. These quantitative measures were used to determine the type and number of self-regulatory strategies vascular sonography students used, their self-efficacy levels, and knowledge and skill performance while learning and performing specified sonographic examinations during a semester –long skills laboratory course. The reason for collecting both qualitative and quantitative data was to converge results from the two forms of data to enrich and bring greater insight into the findings than otherwise would be obtained by either type of data separately.

Research Questions

1. What are the cognitive and motivational issues sonography students encounter while learning sonography and how do the motivational constructs of self-regulation and self-efficacy affect students' abilities to learn sonography?
2. Do sonography students' levels of self-efficacy vary during a semester skills laboratory course as they learn a complex and novel cognitive-motor task, and are there specific events that trigger changes in self-efficacy?
3. What is the relationship between the use of self-regulatory strategies and levels of self-efficacy as it relates to scanning evaluation scores across a semester course that teaches how to perform complex psychomotor and cognitive skills?

Hypotheses

1. The number of self-regulatory strategies students engage in will relate to their scanning performance.
2. Students who are more self-efficacious will both perform better academically and engage in more self-regulatory strategies.
3. Students who are provided with regular written and/or oral instructor/tutor feedback, and who complete self-evaluations on their sonographic skill and performance, this may produce higher self-efficacy levels for sonographic skill acquisition and positively influence it.
4. Students' self-efficacy levels will fluctuate as they progress with their psychomotor skills training and procedural knowledge development in sonography due to the added difficulty of learning simultaneously multiple sonographic skills.

Philosophical Foundations

The specific challenge of understanding how students learn novel, cognitive-motoric tasks in sonography and the multiple skills that must be simultaneously developed to perform them, is a research problem that is multifaceted and has little prior study. Subsequently, this researcher's perspective is that the answer to the problem will be complex as well, and that this study should be carried out while research participants are in the process of learning sonography. This study attempted to identify and relate several factors that most likely were unknown from the student's perspective, and also to validate factors derived from the primary investigator's teaching experience and observations. Therefore, research questions that had both qualitative and quantitative

dimensions and could be categorized as QUAL + quan (meaning research questions that have a more qualitative focus to them, see Creswell & Plano Clark, 2011). Further, it was anticipated that employing a strategy of inquiry that involved collecting and analyzing both qualitative (i.e. open-ended questions and observations) and quantitative (i.e. close-ended questions and scales) data concurrently would be needed to adequately answer the research questions in their complexity. Therefore, a methodological research approach that allowed for the use of multiple methods of data collection simultaneously was deemed to be essential. Specifically, the research approach selected to the present study was a *mixed methods approach* with a *convergent parallel design*, which allowed for both types of research to be collected at the same time. This design was more efficient and permitted the research to be conducted in a manner that mimics how knowledge and skills are observed and learned in real-world practice. For these reasons, a paradigm that supported mixed methods philosophical assumptions was judged to be warranted and found to be typically pragmatistic for the present research study. Pragmatism is derived from the work of well-known historical psychologists and is a worldview that allows for flexibility in research approaches based on its noncommittal stance toward research approach viewpoints. As a result, the current mixed methods approach was able to draw from both qualitative and quantitative research assumptions; therefore addressing the real-world practice constraint. In addition, a pragmatistic view maintained the essence of the research's focus which was on the problem itself and not necessarily on the methods while using a mixed methods approach (Creswell & Plano Clark, 2011).

Researcher Position Statement

I, R.B. Hathaway M.Ed., RVT am identified for the purpose of this research study as the primary investigator. My educational and professional background has been in the fields of health care and education. I am a registered vascular sonographer, an assistant professor and program director for an accredited cardiovascular sonography education program. I began my career in teaching almost 15 years ago. During my time as an educator, I have discovered that not all students in my courses learn sonography in the same manner or achieve the same results during their program of study, which can be frustrating to both the students and instructor alike and a detriment to the program's outcome goals. As an educator my most challenging time instructing students has come while they are enrolled in their beginning skills laboratory courses of the education program. During these courses students need to acquire both a considerable amount of conceptual knowledge and an extensive repertoire of skills to be able to perform sonographic examinations. In most cases, students are able to become successful and competent entry-level sonographers by the end of the program, but not without a considerable amount of instructional guidance and assistance, along with extensive study and practice.

In 2007, the present researcher conducted a survey study for a thesis titled, "Allied Health Sonography Educators' Attitudes Regarding the Need for Psychomotor Skill Testing in Sonography Education Programs" to determine if the challenges encountered by one sonography educator with teaching students could be generalized to other sonography educators and if so, whether methods or techniques could be identified to address these difficulties. Findings of this study showed other sonography instructors

had similar experiences and challenges in teaching sonography (Hathaway, 2007). For example, these sonography educators reported they were instructing students who were still unable to perform sonographic examinations even after having them engage in numerous remedial activities. Additionally, the results showed sonography educators believed there were four psychomotor skills necessary to be competent in sonography. Based on the findings of this study and my personal judgment, the next logical step in this researcher's quest for better understanding of key factors supporting successful sonography education was to explore the cognitive elements involved in performing sonographic examinations and how these elements work in conjunction with the psychomotor skills (procedural knowledge) needed to perform sonographic examinations. An extensive literature review by the present research, however, showed a lack of research on factors affecting how students cognitively process information while performing sonographic examinations and how varied modes of thinking influence their actions. As a result, the present researcher conducted a series of qualitative and mixed methods research studies. From an educator's perspective, being able to understand the relationship between the cognitive and psychomotor aspects of sonographic skill development should be beneficial, especially in teaching those students who have more difficulty with learning sonography. By better understanding the relationship between cognitive and performance dimensions of sonography, it was anticipated that new teaching strategies could be created and used to develop students' sonographic skills more effectively and efficiently.

Based on Hathaway's (2013, 2015) findings, novices do in fact have a considerable variety of thoughts while they perform sonographic examinations and that

these influence how well they are able to perform sonographic tasks. After exploring novices' cognitive processing while they perform sonographic examinations, a better understanding for some of the strategies novices use and common errors or misunderstandings they experience was uncovered. Also, these studies' results pointed to a need to better identify effective and ineffective teaching methods that were being used.

Thus it was that the present researcher- drawing on her prior research on sonographic instruction, on theoretical constructs from her doctoral course work, and on her years of teaching sonography students hypothesized that there may be additional motivational and cognitive factors influencing students' abilities to learn and perform tasks in sonography that have not been well researched. Thus, my goal as an educator and as lead investigator in the present study was to identify cognitive and motivational challenges encountered by sonography students, and try to gain an in-depth understanding of how these challenges might affect students' abilities to learn sonography. Specific goals for the study were exploring the motivational constructs of *self-regulation* (Schunk & Zimmerman, 1997) and *self-efficacy* (Bandura, 1986), and their relationship to students' academic performance. Ascertaining how specific motivational constructs affect students' abilities to learn complex skills sets, as in sonography, may have the potential to improve both the caliber of applied health care education outcomes and educators' instructional skills alike.

Definition of Terms

Sonography: A profession in the healthcare field that requires individuals to obtain images inside of the body during a diagnostic medical procedure referred to as an

ultrasound, which is requested and interpreted by a physician (Society of Diagnostic Medical Sonography Board of Directors, 2004).

Sonographer: A highly-skilled professional who uses specialized devices to generate images of structures within the human body that are used by physicians to formulate a medical diagnosis (Society of Diagnostic Medical Sonography, 2006).

Ultrasonic/Sonographic Machine or Equipment (Ultrasound Machine): Diagnostic medical devices that are used to produce medical images (sonograms) (Society of Diagnostic Medical Sonography, 2005).

Ultrasonic/Sonographic Examination/(Ultrasound Study): A routine diagnostic medical procedure that uses high frequency sound waves to create images (sonograms) of organs, tissues, or blood flow inside the body by emitting sound waves from a hand-held transducer and converting returning sound waves into electrical impulses to be displayed on a computer monitor (Rados, 2004; Society of Diagnostic Medical Sonography, 2006).

Psychomotor Skill: The mental process associated with muscular movement and to the production of voluntary movements (Dirckx, 1997).

Hand-Eye Coordination: The skills of perception and manual dexterity used concurrently to accomplish a specific task.

Spatial Orientation Skill: The ability for individuals to perceive and hold in their minds a 3-dimensional object and its scale as a whole while viewing it as a 2-dimensional image (Smith, 1989).

Perception Skill: The ability to view and conceptualize an image on a computer monitor traveling in the opposite direction than the hand that is moving the transducer (Hathaway, 2007).

Manual Dexterity Skill: The demonstration of fine hand movements (Spratley, 1990).

Accredited: Education programs that uphold an established set of standards from the accrediting body for allied health sonography education programs, which is the Commission on Accreditation of Allied Health Education Programs (CAAHEP) (Commission on Accreditation of Allied Health Education Programs, 2006; Commission on Accreditation of Allied Health Education, 2005).

CHAPTER 2

Methods

Mixed Methods Convergent Parallel Design

According to Creswell and Plano Clark (2011) mixed methods research is a design that has philosophical assumptions and methods of inquiry that began to grow in popularity in the late 1980's. Mixed methods, as the name implies, mixes both qualitative and quantitative research practices. The mixed methods approach is beneficial to the researcher who has research problems or questions that would be difficult to address by using a qualitative or quantitative approach alone, which is the case for this research study. Although collecting both qualitative and quantitative data simultaneously can be an added constraint; therefore, having the option to be able to use both qualitative and quantitative approaches at the same time within this research study, provided the investigator with an approach that corrected this dilemma (Creswell & Plano Clark, 2011). More specifically, choosing the mixed methods design referred to as convergent parallel allowed for both qualitative and quantitative data collection to occur concurrently, by further assisting this research study. Even though both data sets were collected at the same time, they were still analyzed separately using the appropriate qualitative and quantitative techniques. Then, the results from each analysis were merged within the discussion. Lastly, an interpretation was formed from the merged results, following Creswell and Plano Clark's description of a convergent parallel design. A visual design diagram (see Appendix A) has been developed to illustrate how the convergent parallel design occurred for this research study.

The challenges of selecting the convergent parallel design that were specific to this study included the following. The first challenge with choosing to use the convergent parallel design was the limited amount of expertise that the primary and secondary investigators have with concurrent data collection, which requires the execution and orchestration in unison of the qualitative and quantitative research techniques. A solution to this challenge was to seek the advice and resources of a more experienced researcher who had familiarity with data collection in a mixed methods convergent parallel design. An equally challenging task was then to merge the two separate data sets in order to arrive at an interpretation that addressed the research problem that could not be answered without combining both the qualitative and quantitative data. Merging of the two data sets occurred as a part of the discussion for this study.

Participants

Sample. Participants in this study were 13 undergraduates (11 females, 84%) enrolled in a vascular sonography skills laboratory course, which was a part of a cardiovascular sonography program for a Bachelor of Science in Health Professions degree for students with no prior training in vascular sonography. Although all research participants began with no prior vascular sonographic skills training, there were some students who had instruction and training in adult cardiac sonography. The research study began early in the participants' vascular sonography skills training, Weeks 1 and 2. The students' training included formal instruction with an instructor and a peer mentor during three-hour weekly skills laboratory sessions that had no more than a 6:1 student-to-instructor ratio. In addition to the formal instruction, participants were required to

engage in a minimum of 3-4 hours each week of self-regulated sonographic skills practice scanning assignments. The weekly practice was performing sonographic examinations according to set guidelines, the skills for which were taught during the instructor-led skills laboratory sessions. The participants had one week on average to complete the sonographic skills practice scanning assignments. After completing each of the assignments, students were required to complete self-critiques for each of them indicating their strengths and areas of improvement for each one. After self-critiques were completed, students determined which assignment was most representative of their best skill level. The student submitted this chosen assignment for grading and was provided instructor feedback. In addition to weekly instructor feedback, students had available to them instructional videos for each of the different types of examinations that they learned how to perform and sample images of the anatomy. These instructional materials were available to be viewed an unlimited number of times. The names and contact information for the participants were obtained from the sonography skills laboratory course rosters that the primary investigator had access to for this course. Since the primary investigator was the lead instructor for the participants who were studied, the secondary investigator who did not have affiliation with the study site or its students recruited the participants using a script (see Appendix B) and obtained informed consent (see Appendix C) from them. Recruiting by the impartial secondary investigator was planned in order to minimize perceived coercion by the participants.

Procedure

After informed consent was obtained from the participants the first set of measures were administered, using a series of instruments developed by the primary investigator.

To assess participants' levels of self-efficacy, participants were asked to complete a practice self-efficacy scale (identified to the participants as the practice appraisal inventory) reprinted from Bandura's (2006) *Guide for Constructing Self-Efficacy Scales* (see Appendix D). The practice self-efficacy scale was used to assist participants in familiarizing themselves on how to complete such a scale. Immediately following the practice self-efficacy scale the actual self-efficacy scale developed for this study (identified to the participant as an appraisal inventory) (see Appendix E); utilizing Bandura's (2006) *Guide for Constructing Self-Efficacy Scales* as a reference was administered with a brief statement reviewing the purpose of the study (see Appendix F). Participants were asked to complete the self-efficacy scale a second time, during Week 7 of the semester, after being taught all of the procedural steps and skills for a carotid duplex exam. The Week 7 self-efficacy scale administration was scheduled just before the first practical quiz test-out on the carotid duplex examination, which was performed live in front of the instructor. The self-efficacy scale was administered to participants a third time during Week 11 before participants completed another carotid duplex exam. Participants were asked to complete the self-efficacy instrument a final time towards the end of the semester during either Weeks 15 or 16, before participants performed their final practical test outs.

Students' self-regulatory strategy usage was investigated through a weekly survey (see Appendix G) that was conducted either through the online survey management company, Survey Monkey, or with a hardcopy paper version based on the online survey management company's survey template. The weekly survey consisted of 13 items developed by the investigator that were used to assess which self-regulatory activities participants were involved in during the week, the amount of practice and study time participants expended towards vascular sonography, reasons why they believed the amount of practice and study time indicated was insufficient, the goals participants set for themselves for the next week and a progress report on goals that were previously set by participants. Each week participants were sent a link to the survey at the end of their skills laboratory session and a reminder to fill out the survey promptly (within two days of receiving the survey link) or they were handed directly a hardcopy version and instructed to submit the survey one week later. A total of 15 weekly surveys were administered to participants throughout the semester. There was no survey in Week 14 due to a national holiday break and because skills laboratory courses were not in session or the last week due to the final examinations that mark the end of the semester.

Academic performance was assessed weekly through viewing skills laboratory assignments completed by participants and observations/interactions with participants using instructor evaluations of participants' scanning performance specific to the type of examination(s) being taught that week (see Appendix H-scanning evaluation of carotid duplex exam). The instructor used these evaluations to assess participants' knowledge and skill levels as well as to provide instructional feedback to students about their sonographic knowledge and skill techniques, goal attainment, and overall weekly

academic performance. A detailed outline of the schedule for when all research measures were administered throughout the semester was included as a part of this research study (see Appendix I).

As participants completed the previously described measurements for the research study and regularly scheduled course requirements, participants also on a weekly basis attended an assigned instructor-led three-hour skills laboratory session. During the skills laboratory sessions knowledge and skills associated with a carotid duplex examination and eventually several other types of vascular sonography examinations were taught. However, before attending these required skills laboratory sessions participants were directed to view recommended videos that demonstrated the steps and skills that were to be performed by the faculty member teaching the skills laboratory session's subject matter, while also reviewing a written set of procedural steps that correlate with the video demonstration. In addition to viewing the video, participants had access to expert produced sonographic images that they were encouraged to view in conjunction with the video. Ideally, providing participants with the videos, images, and procedural step resources prior to attending skills laboratory sessions were anticipated to establish a block of prior knowledge and initiate a schema acquisition process for that set of skills, which is deemed as a critical element to a theory known as cognitive load and its theoretical framework (Kalyuga, Chandler, & Sweller, 1998). Based on cognitive load theory providing students with access to the declarative and procedural knowledge needed for performing vascular sonographic examinations was judged to have likely a positive effect on both their working memory load during the skills laboratory sessions and decrease the

amount of intrinsic cognitive load with the material that was required to be learned (Plass et al., 2010).

Once participants arrived to the skills laboratory sessions where the skills for that week were taught, participants viewed in most cases a peer model, someone who had learned the skills the year prior, demonstrated the tasks for the weekly sonographic examinations learned. According to Schunk (1985) peer modeling has been shown to have several benefits in learning new content. Immediately following this demonstration the participants were required to practice the skills by role playing and working through the procedural steps of the sonographic examinations with one or two of their classmates while receiving assistance from the teaching faculty member for the laboratory session and/or the peer model.

Upon completion of the skills laboratory session, participants had one week to complete a minimum of three additional sonographic examination assignments based on the protocol assigned for that week, this allowed for deliberate practice of these skills to take place (Ericsson et al. 1993). By following Ericsson et al.'s (1993) deliberate practice framework the belief was that participants would be able to work more effectively towards increasing their skill level and maintain it.

After completing all sonographic examination assignments for the week, participants chose the one examination he or she believed was the most representative of their current skill level that week for grading and instructor feedback. In addition, participants were required to complete and submit self-critiques of their technical and professional skills for each of their sonographic assignments. The graded sonographic examination assignment was reviewed and assessed by the instructor based on six clinical

behavioral categories: *technical skills, critical thinking, professionalism/accountability, organization, patient/sonographer interaction, and safety.*

As the research study began with Weeks 1 and 2 of the semester for vascular sonography skills training, the research study participants learned the different procedural steps and skills that were associated with a carotid duplex examination. The carotid duplex examination was taught divided into sections with each week building on the previous sections. As a result by Week 4 of the semester participants had been taught all of the steps and skills associated with a carotid duplex examination. Approaching vascular sonographic instruction by using what was previously introduced as *scaffolding* approach was hypothesized to lessen both intrinsic and extraneous cognitive loads (van Merriënboer, Kirschner, & Kester, 2003). Teaching participants a carotid duplex examination first was strategically decided upon for its ease as compared to the other required sonographic examinations in locating anatomy, which tends to be larger, more superficial within the body, and have not as many anomalies and with fewer vessels needing to be learned. Lastly, carotid duplex examinations appear to have a significant number of skills associated with them that can be learned and transferred to the other types of vascular examinations that were also learned in the subsequent weeks of the research study.

Overall, the instructional method described above that includes a considerable amount of deliberate practice and regular instructor feedback is designed to assist participants through the process of learning complex skills required in sonography. As participants are instructed with the scaffolding approach they will also be provided with intentional increased assistance at the beginning of their sonography training, gradually

diminishing levels of this support in subsequent weeks of instruction. This practice is consistent with the 4C/4ID van Merrienboer (1997) methodology.

Based on the work of van Merrienboer (1997) with the 4C/ID mode coupled with information presented in van Merrienboer (2003) on part-task approaches, a curriculum plan that incorporated both of these methodologies was used to teach research participants. The approaches previously described for vascular sonography instruction were intended to address the cognitive load challenges of decreasing intrinsic and extraneous cognitive loads—a methodology that the primary investigator has been using for the last several years to assist students in learning vascular sonography.

The time frame for acquiring all of the knowledge and skills associated with a carotid duplex examination was four weeks. At the end of four weeks, an additional two-three weeks was given to participants to continue to work on the knowledge and skills taught for a carotid duplex examination and receive feedback about them while being introduced to and learning the knowledge, procedural steps and skills related to a different type of sonographic examination. While the knowledge and skills were being practiced simultaneously versus separately, the instruction can be described as a whole-task focused practice (van Merrienboer, 2003). During Week 8 of the skills laboratory course that the research study was conducted in, participants engaged in the first practical quiz test out for the research study and the course, the carotid duplex examination. The carotid duplex examination was performed live in front of the instructor while at the same time another classmate was also performing their practical quiz test out separated by a curtain.

In the weeks to follow after the first practical quiz test out participants learned how to perform other sonographic examinations in a similar manner as the carotid duplex examination was completed, while periodically practicing the performance of a carotid duplex examination. Participants were also required to complete additional practical quiz test outs for other types of sonographic examinations, which were recorded and viewed by the instructor at a later time; therefore not live and in front of the instructor like the first carotid duplex practical quiz test out. The practical final test outs were either completed live or recorded and viewed by the instructor at a later time.

Qualitative Data Collection

Data collection took place throughout the fall semester in a 16-week semester-long vascular sonography skills laboratory course. Qualitative measures included using the following: (1) a weekly survey developed for this study and, (2) instructor evaluations of participants scanning performance used previously in the vascular sonography laboratory course as assessment tools, and (3) the primary investigator's observations and interactions with participants.

Weekly survey. A 13-item survey included open and close-ended questions collecting qualitative data focusing on the participants' self-regulatory activities. Participants were asked to report about the amount of practice and study time they expended towards vascular sonography, such as reasons why they believed the amount of practice and study time indicated was insufficient, self-set weekly goals, and a progress report on previously set goals. Participants were indicated to complete 15 of the surveys on a weekly basis throughout the semester to obtain an adequate return rate and not require participants to have to report more than a week's worth data at one time; possibly

providing a more accurate reflection of the results. However, only a sampling of four weekly surveys out of the 15 were used to analyze the data, which came from selecting them evenly throughout the semester. To assist in the data collection phase for this measure, data was recorded either through the online survey management company, Survey Monkey, or with a hardcopy paper version based on the online survey management company's survey template and transferred or exported to an Excel file.

Instructor evaluations of participant scanning performance. Each participant was evaluated on their sonographic skill performance, specifically their ability to perform sonographic examinations on a weekly basis. These scanning evaluations were developed by the primary investigator and regularly used for weekly assessments of participants' performance in the sonography skills laboratory. Participants' sonographic knowledge and skill levels in the following course objective categories of technical skill, critical thinking, professionalism/accountability, client/sonographer interaction, organization, and safety were rated as either exceeding expectations, meeting expectations, or not meeting expectations. Also included on these evaluations was the primary investigator's feedback about participants' sonographic skill performance obtained by reviewing participants' recorded and live sonographic examination performances. Fourteen evaluations on each participant were completed by the instructor about the participants' performances and four of those fourteen included as a part of the data analysis. To assist in the data collection phase for this measure, assessments of participants' scanning performance and instructor feedback were recorded using the instructor scanning evaluation form (Appendix H) and transferred to an Excel file.

Primary investigator's observations and interactions with participants. The primary investigator holistically observed and interacted with the participants during class periods, practice sessions, and one-on-one meetings throughout the semester. Memoing and notetaking were utilized to record these observations and interactions of participants. Memos and notes were later transferred to a Word document to be digitally recorded.

Quantitative Data Collection

Data collection took place throughout the fall semester in a semester-long vascular sonography skills laboratory course. Quantitative measures included the following: (1) a weekly survey developed for this study (used also in qualitative data collection) and, (2) a self-efficacy scale (appraisal inventory) developed for this study; utilizing Bandura's (2006) *Guide for Constructing Self-Efficacy Scales* as a reference. An additional measure used for both qualitative and quantitative data collection was (3) instructor evaluations of participants scanning performance used previously in the vascular sonography laboratory course as assessment tools.

Weekly survey. A 13-item weekly survey developed by the investigator was used to assess self-regulation. The quantitative data collected by the survey included both the type and number of self-regulatory activities participants reported being involved in during the week, and the amount of practice and study time participants expended towards vascular sonography. Participants were indicated to complete 15 of the surveys on a weekly basis throughout the semester to obtain an adequate return rate and not require participants to have to report more than a week's worth data at one time; thereby possibly providing more accurate results. However, only a sampling of four

weekly surveys out of the 15 were used to analyze the data, which came from selecting them evenly throughout the semester. To assist in the data collection phase for this measure, the techniques described for qualitative data collection were also used with the quantitative data.

Self-efficacy scale. Immediately following the completion of a practice self-efficacy scale, an initial self-efficacy scale (identified to the participant as the appraisal inventory) was administered to participants. This self-efficacy scale was developed for this study, utilizing Bandura's (2006) guide as a reference. This instrument was designed to measure participants' self-reported perceived self-efficacy levels on specified sonographic skills or tasks on a rating scale from 0 to 100. A rating of zero on the scale indicated "cannot do at all", a rating of 50 indicated moderate certainty of successful performance, and a rating of 100 indicated complete certainty the skill could be completed. Participants completed this self-efficacy scale four times during the semester in weeks 1, 7, 11, 15. To assist in the data collection phase for this measure, data was recorded either through the online survey management company, Survey Monkey, or with a hardcopy paper version based on the online survey management company's survey template and transferred or exported to an Excel file.

Instructor evaluations of participant scanning performance. Each participant was evaluated and provided with feedback on their sonographic skill performance, specifically their ability to perform sonographic examinations. These scanning evaluations were developed by the primary investigator and previously utilized for weekly assessments of participants' sonographic skill performance. Participants' sonographic knowledge and skill levels were rated in the following course objective

categories of technical skill, critical thinking, professionalism/accountability, client/sonographer interaction, organization, and safety were rated as either exceeding expectations (2 points), meeting expectations (1 point), or not meeting expectations (0 points). To assist in the data collection phase for this measure, the techniques described for qualitative data collection were also used with the quantitative data.

Data Analysis Methods

Qualitative

Data analysis began with exploring the data, one of the first steps in the process of analyzing data in mixed methods research as identified by Creswell and Plano Clark (2011). Exploration of the data began with the primary investigator reviewing the open-ended responses on the weekly survey several times to develop a general understanding of the database (as suggested by Creswell & Plano Clark, 2011). As recommended by Creswell (2014) open-ended responses were then re-read and significant statements describing the participants' explanations were noted by the primary investigator. These original statements about the participants' responses were then developed into codes. Next, the primary investigator discussed her initial reactions and potential codes for representing key statements from the participants with a peer debriefer, a process Creswell has recommended for enhancing the accuracy of intent for participants' responses. This person reviewed and asked questions of the primary investigator about the qualitative study so that the research would resonate with people other than the investigator herself. After responses and codes were discussed, they were combined into overarching themes.

The data analysis process continued for the qualitative measure, instructor evaluation of participants' scanning performance, as a similar process to what was used for the weekly survey, as recommended by Creswell (2014). Data analysis began with reviewing the written instructor feedback on four weekly scanning evaluations from weeks 3, 7, 11, and the last week of the semester several times. Feedback on each participant was read in its entirety for overall understanding by the primary investigator. The feedback was re-read and an interpretation made by the primary investigator. The primary investigator discussed her initial interpretations with a peer debriefer. After this discussion, the primary investigator revised her interpretations based on the peer debriefer's recommendations to further condense and present the interpretation of the instructor feedback in a manner that answered the research questions.

Lastly, data from the primary investigator's observations and interactions with participants were analyzed by the researcher's first reading through memos and notes generated by observing them inside of the skills laboratory and in one-on-one meetings with them. After reading and re-reading these records, the primary investigator reflected also on participants' performance levels and overall feedback that she had provided to them throughout the entire semester. Based on this analysis, the primary investigator made judgments about participants' cognitive ability and grouped them according to it. Validation for the accuracy of these judgments made about participants' cognitive ability is based on the extended amount of time she had spent with these participants, which was an entire semester. Resulting in having numerous interactions with them and more of a familiarity about their cognitive abilities. Being with the participants for a prolonged period of time as an investigator is recognized by Creswell (2014) as a data validity

strategy. Also, the primary investigator's substantial teaching experience of almost 15 years with instructing and evaluating students in this capacity is believed to support the validity of this qualitative measure as well.

Overall, the data was analyzed through detailed procedures that relied upon using one of Strauss and Corbin's (1990) grounded theory principles as cited in Creswell (2007), which included open coding and identifying from these codes the major themes. The codes and themes came primarily from data collected on the open-ended questions with the weekly survey, instructor evaluations of participants scanning performance, and the primary investigator's observations and interactions with the participants on a weekly basis over an extended period of time, throughout a semester-long skills laboratory course. According to Teddlie and Tashakkori (2009) using multiple forms of data collection provides for increased validation of the data and an in-depth analysis of it. As a result, using the weekly survey, instructor evaluations of participants scanning performance, and the primary investigator's observations and interactions with participants resulted in employing a validation strategy, known as triangulation of data. One of many strategies described by Creswell (2014) as ensuring internal validity when data is collected through multiple sources.

Quantitative

Basic descriptive statistics was used to calculate frequencies, percentages, and measures of central tendency (mean and median). The quantitative data collected for the weekly survey, self-efficacy scale (appraisal inventory), and instructor evaluations of participants scanning performance. All statistical analysis of the quantitative data was analyzed using Excel and conducted with the aid of a statistician.

Mixed Methods

The analytical strategy used for the integration of the qualitative and quantitative data was *typology development*. According to Plano Clark and Creswell (2008), typology development occurs when "...the analysis of one data type yields a typology that is then used as a framework applied in analyzing the contrasting data type" (p.235). For this study, the quantitative data yielded a typology that was then used as a basis in analyzing the qualitative data.

Further analysis of the data included two other stages referred to as "data reduction" and "data display". These two stages were a part of a data analysis process discussed by Onwuegbuzie and Teddlie (2003) and cited in Creswell and Plano Clark (2011). Data reduction as described by Onwuegbuzie and Teddlie refers to reducing data collected by (1) statistical analysis of quantitative data and (2) summarizing the qualitative data. In the present study, statistical analysis of the quantitative data was applied to data from the weekly survey, self-efficacy scale, and instructor evaluations of the participants' scanning performance. These data were analyzed using basic descriptive statistics.

The qualitative data, which was collected from the weekly survey, included instructor evaluations of participants' scanning performance, along with the primary investigator's interactions and observations of participants was summarized as themes. Data display, the second stage used for data analysis, also was used to reduce the quantitative data by presenting it primarily as graphs and in one table, while the qualitative data was reduced to primarily themes, participants' quotes, and one table.

Validity Approaches

The following strategies were used to ensure validity of the qualitative data, all of which are recommended by Creswell (2014) to validate qualitative data.

1. Triangulation
2. Long terms and repeated observations at the research site
3. Peer examination
4. Clarification of researcher bias

The quantitative data for this study, in contrast, was validated in terms of its *content validity* (Creswell & Plano Clark, 2011). According to Creswell and Plano Clark, content validity is a form of validity that can be implemented when a similar instrument is unavailable to be used as an external standard. In the present study, content validity mainly was used to validate mainly the instructor evaluations of participants' scanning performance. This approach was developed by the primary investigator, who has almost 15 years of experience assessing individuals' sonographic knowledge and skills successfully, and have used such evaluations for assessment purposes the last 12 years with only minor revisions made to it.

The self-efficacy scale likewise was validated by means of a content validity approach since there were no comparable instruments that could be used. The self-efficacy scale was developed and used for this study was constructed based on Bandura's (2006) work, "Guide for Constructing Self-Efficacy Scales". Bandura is a well-known and respected researcher, who has specialized in self-efficacy instrumentation and administration.

Researcher's Resources and Skills

The primary investigator's resources included 24-hour, seven-days a week access to the skills laboratory and its sonographic equipment, along with full availability to the instruments for this research study. The names and contact information for the participants were obtained from the sonography scanning course rosters, which were accessible to the present investigator as the primary instructor for these courses.

The professional skills of the primary investigator were as follows. She is a registered vascular sonographer, obtaining this registry in the fall of 2003. The primary investigator also has achieved proficiency in performing sonographic examinations through training in a CAAHEP accredited sonography education program. She graduated from Southeast Technical Institute in July of 2003 after an extensive seven-month clinical practicum at a primary level medical center.

The primary investigator also has experience not only in clinical practice, but also in instruction, having taught courses and developed curriculum for applied health care students, specifically for sonography, since December, 2004. In terms of research experience, the primary investigator has completed graduate course work in both quantitative, qualitative, and mixed methods research and based on this course work has both written research proposals and conducted studies based on these research proposals.

IRB and Ethical Considerations

The primary investigator requested obtained permission to conduct this study from the college's Internal Review Board where the primary investigator was employed and where the research was performed. The Internal Review Board of the university where the primary investigator engaged in scholarly study also requested the study be

sent to them for review. During the recruitment of participants and the obtaining of informed consent phases in the present research study, the primary investigator was not involved if she held the role of the participants' instructor for the course in which the research study was conducted in. Instead, a secondary investigator was the person conducting these phases of the research study to avoid the perception of coercion when asking students to participate in this study.

Any information that was obtained during this study that could have identified the participants was kept strictly confidential. The primary and secondary investigators were the only individuals to have access to the information completed by the participants. To maintain research subject confidentiality research participants were assigned a code and this was their only identifier on the weekly surveys and self-efficacy scales. The secondary investigator assigned and distributed codes to research participants for these two measures. Other research data originally recorded on paper while research participants were engaging in the research was also coded and saved to a secured hard drive and the hard copy destroyed after the investigators transferred it to a digital format. If the information obtained is published in scientific journals or presented at scientific meetings, the data will be presented with code identifiers.

Discussion of Research Findings for Qualitative Study and Pilot Study

In the spring of 2013, Hathaway conducted a pilot study to collect data for a qualitative study titled, "Mind and Fine Motor Control: The Thought Process of Students While Performing Sonographic Procedures". The pilot study had three participants who were sonography students with 16 weeks of vascular sonography instruction at the time they participated in the pilot study. The participants performed a unilateral left-sided

carotid duplex examination using a Philips HD11 XE ultrasound system (Philips Healthcare, Bothell, Washington) while verbalizing all of their thoughts, or “thinking aloud”. The images obtained by the participants were digitally archived. The reason for using specifically the aforementioned piece of sonographic equipment for the pilot study was because all three participants had familiarity with using it when performing carotid duplex examinations.

The procedure for the pilot study began by evaluating one participant at a time in a private skills laboratory setting with that participant and the primary investigator. Each participant was requested to engage in a practice exercise of thinking-aloud by reading an excerpt from an ultrasonography textbook that described in detail how to perform a carotid duplex examination as they verbalized all of their thoughts aloud. Upon completion of the practice session, participants were told that they were not obligated to perform the examination in the manner by which the excerpt they just read described and could decide to perform the procedure in the manner they preferred to do so. Participants were also told that reading the excerpt is not an exercise in reading aloud, but is a task that focuses on expressing verbally their ideas and reasoning as they encounter the information.

Immediately following the think-aloud practice session, participants were instructed to begin performing a right-sided carotid duplex examination and verbalize all of their thoughts while engaging in this task in front of the primary investigator. After completing the think-aloud session while performing the carotid duplex examination, participants were asked to express how they felt the think-aloud session went for them. The following content are participants’ responses from the brief open-ended interview.

Participant 1 Responses: The first participant expressed how the exercise felt like a test which induced anxiety. The participant relayed that they had not thought aloud before while performing sonographic examinations. The participant also indicated that in retrospect they should have used a different technique to perform the carotid duplex examination than they did.

Participant 2 Responses: The second participant expressed they felt completing a carotid duplex in their education at this point was easier to do since they have been scanning for a while now, and they did not have to think about their hand movements, but can instead focus on getting a better image. Also, the participant said the mechanical skill is there, so they were not worried about the thought of just getting an image, but thinking now how do they make the image better instead.

Participant 3 Responses: The third participant commented that there were many words bouncing around in their head, but it was more difficult getting those words out of their mouth in a coherent manner.

After conducting the pilot study there were items that were in need of further revision to better the research study's design. Those revisions were implemented and the qualitative study was conducted based on the findings of the pilot study in the Fall of 2013.

In the Fall of 2013, the study had eight participants who were students with 5 weeks of vascular sonography instruction at the time they participated in the study. All eight students performed a unilateral right-sided carotid duplex examination using a Philips HD11 XE ultrasound system (Philips Healthcare, Bothell, Washington), a system

all participants had used prior and were familiar with using for this type of study. The sonographic images obtained by the participants were digitally archived.

The procedure for this qualitative study began by evaluating one participant at a time in a private skills laboratory setting with only that participant and the primary researcher. Each participant was requested to engage in a practice exercise of thinking-aloud. As a part of this think-aloud exercise participants first viewed a live demonstration by the investigator of how to think-aloud while using a device called a “Star Tracer”. The “Star Tracer” is a device designed to assess an individual’s level of motor sensory or psychomotor skill (hand-eye coordination), by having an individual use a hand-held pencil-like stylus attached to a string and trace around a star by viewing the image of the star in a mirror. Although assessing hand-eye coordination is the primary purpose of the “Star Tracer” it was not evaluated as a part of this study and the device was only used as a practice exercise to think aloud while engaging in a task that requires one of the psychomotor skills deemed necessary for sonography (Hathaway, 2007). While performing the sonographic examination and practice exercise participants were asked to think-aloud every thought that they had on their minds and verbalize them in a normal speaking voice. If at any time there was a period of silence for 15 seconds or more, the primary investigator provided participants verbally with a reminder to think-aloud in the form of the question, “What are you thinking now?”

Upon completion of the think-aloud practice exercise, participants began performing a unilateral right-sided carotid duplex examination while thinking-aloud. A digital video camera recorded the practice and scanning sessions of the study. The video camera was set-up to record the participant’s scanning hand with transducer movements

and what was being shown on the sonographic machine's screen during this session, while capturing the participants' thoughts as they verbalized them.

The volunteer (the individual being examined with the sonographic procedure) was a person that none of the participants had performed a carotid duplex exam on prior to this research study. However, the volunteer did have a carotid duplex examination completed prior to the beginning of the research study by the primary investigator, who was also a registered vascular sonographer, to determine if the volunteer's anatomy was suitable for it. The volunteer was informed of this information and asked to disregard any other information about their anatomy that is verbalized by research participants during the study because of its potential for inaccuracy.

During each participant's think-aloud carotid duplex examination session: the primary investigator recorded notes on the participants' comfort and skill level while scanning, how difficult it was for the student to think-aloud, the quality of images that participants acquired during the scanning procedures. All practice and think-aloud carotid duplex examination sessions occurred in a sonography skills laboratory. Immediately after each think-aloud carotid duplex examination session, participants were interviewed privately through a brief, open-ended question interview about their thoughts regarding the think-aloud process while performing the examination. Participants were asked, "Tell me how you feel about this experience."

After analyzing the data using grounded theory principles, which included observing participants, memoing, and open-ended question interviewing several themes emerged. The first theme that emerged from the data involved the types of strategies students use while they perform a unilateral carotid duplex examination with only five

weeks of sonographic skill training. One of those strategies participants were identified using was a “trial and error” method to work through more challenging areas of the examination, which resulted in those participants taking more time to complete the task and being more frustrated while performing it. Other strategies participants used were provided by their instructor during their earlier weeks of training. The instructor-provided strategies appeared to be more beneficial to participants than the “trial and error” method in completing sonographic tasks. Some participants were also observed thinking of alternative or multiple strategies when they encountered difficulty while completing the think aloud carotid duplex examination session. Those participants who did not think of and express different strategies while working through challenging aspects of the examination appeared as having a lower level of confidence at these times based on observations of the thoughts participants shared during those moments, a second theme that became evident. Although these participants may have experienced periods of lower levels of confidence, they also exhibited increased levels of confidence for other portions of the examination that were not as challenging to perform for them. The observed fluctuations in confidence appeared to have an impact on their performance of a unilateral carotid duplex examination—an important observation and theme that should be further researched and assessed in terms of self-efficacy levels.

A third theme that emerged from the data was the ease of identification for areas of a carotid duplex examination that students still needed additional help with, which included: proper adjustments to color scale and gain, color box steering, vessel identification visually with or without color Doppler and with spectral waveform analysis, mirror image artifact, and spectral scale adjustments. Based on the ease by

which student deficiencies and strengths could be identified during the think-aloud carotid duplex examination session, a recommendation to sonography educators is to implement within their courses think-aloud studies with their students or even a sampling of them to determine students' level of skill acquisition and skills that require further development.

A last and significant theme identified from the data showed students primarily think only about the examination protocol itself and rarely diverge from this train of thought while completing carotid duplex examinations with only five weeks of sonographic skills training. Suggesting that students may have not yet fully automaticized accessing their declarative and procedural knowledge, in turn, would decrease working load capacity for performing sonographic examinations. Recommending that sonography educators who are teaching students particularly in their early weeks of sonographic skills training to provide them with a clear and concise protocol to follow and limit any unnecessary distractions that may impede their focus while learning.

Discussion of Research Findings for Mixed Methods Study

In the fall of 2015, a mixed methods study based on the methods of the qualitative study conducted in the fall 2013 was conducted with ten participants who were students with 5 weeks of vascular sonography instruction at the time they participated in the study. All ten students performed a unilateral right-sided carotid duplex examination using a Philips HD11 XE ultrasound system (Philips Healthcare, Bothell, Washington), a system all participants had used prior and should have been familiar with using for this type of study. The sonographic images obtained by the participants were digitally archived.

The procedure for this mixed methods study began by evaluating one participant at a time in a private skills laboratory setting with only that participant and the primary investigator present. Each participant was requested to engage in a practice exercise of thinking-aloud. As a part of this think-aloud exercise participants first viewed a live demonstration by the primary investigator of how to think-aloud while using a device called a “Star Tracer”. The “Star Tracer” is a device designed to assess an individual’s level of motor sensory or psychomotor skill (hand-eye coordination) by having an individual use a hand-held pencil-like stylus attached to a string and trace around a star by viewing the image of the star in a mirror. The participants were then instructed to think aloud all thoughts they had and verbalize them in a normal speaking voice while performing the “Star Tracer” task. If at any time there was a period of silence for 15 seconds or more, the primary investigator provided participants verbally with a reminder to think-aloud in the form of the question, “What are you thinking now?” Then participants performed three separate, but consecutive attempts of the “Star Tracer”. The number of errors (tracing with the stylus outside of the star’s perimeter) were recorded by the device and related to the participants’ level of motor sensory ability or hand-eye coordination for each attempt. The more errors made by the participants equaled a decreased level of motor sensory ability or hand-eye coordination for them. Immediately following the “Star Tracer” task, participants were asked to classify the level of difficulty they perceived performing the “Star Tracer” was for them. For example, they were asked to report if the task was either “not difficult”, “somewhat difficult”, “difficult”, or “very difficult”.

Upon completion of the think-aloud practice exercise, participants began performing a unilateral right-sided carotid duplex examination while thinking-aloud. A digital video camera recorded the practice and think-aloud carotid duplex examination sessions of the study. The video camera was set-up to record the participant's scanning hand with transducer movements and what was being shown on the sonographic machine's screen during this session, while capturing the participants' thoughts as they verbalized them.

The volunteer (the individual having the sonographic procedure performed on) was a person that none of the participants had performed a carotid duplex examination on prior to this research study. However, the volunteer did have a carotid duplex examination completed prior to the beginning of the research study by the primary investigator, who was also a registered vascular sonographer, to determine if the volunteer's anatomy was suitable for this study. The volunteer was informed of this information and asked to disregard any other information about their anatomy that was verbalized by research participants during the study because of its potential for inaccuracy. The volunteer also wore headphones while listening to music during the think-aloud sessions to assist in preventing the overhearing of the participants' verbalized thoughts.

During each participant's think-aloud carotid duplex examination session, the primary investigator recorded notes on the participants' observed comfort and skill level with performing sonographic examinations while scanning, how difficult it was to think aloud while performing a carotid duplex examination, the quality of images that participants acquired during the scanning procedures, the errors and more challenging

portions of the examination for participants, the areas of the examination participants performed well, and the strategies students used to during this think aloud session. Practice and think-aloud carotid duplex examination sessions occurred either in a sonography skills laboratory or a classroom. Immediately after each think-aloud carotid duplex examination session, participants were interviewed privately through a brief, open-ended question interview about their thoughts regarding the think-aloud process while performing the examination. Participants were asked, “Tell me how you feel about this experience.”

Approximately one week after the think aloud carotid duplex examination session was completed and the brief interview took place, a secondary interview was conducted. This second interview took approximately 15-20 minutes of participants’ time and was conducted in a classroom. The primary investigator and the participant reviewed together the images from the think-aloud carotid duplex examination session. While reviewing the sonographic images and recalling the events and thoughts that took place during the think-aloud session additional information about the participants’ thoughts and their reasoning for their actions were recorded. Digital video cameras recorded the practice, think-aloud with sonographic examination performance, and interview sessions of the study.

After analyzing the data using grounded theory principles, several themes emerged as they had occurred with the aforementioned qualitative study. The major themes that emerged for this mixed methods study were the same ones identified for the qualitative study. Further validating the importance of having students perform sonographic examinations while thinking aloud and the instructor observes these sessions

and reviews the outcomes of them with the students in order to discuss their strengths and areas for improvement for sonographic skill acquisition.

Conclusions and Implications of the Study for Research and Practice

Uncovering how the motivational constructs of self-regulation and self-efficacy influenced sonography students' performance early in the learning process has provided the potential to assist students and educators with learning sonography through a myriad of possibilities. For example, through opportunities for improved teaching strategies, curriculum models, and theories that assist students in learning the knowledge and skills needed in sonography in a more efficient timeframe, with reduced frustration, and in a more effective manner to be implemented. Therefore, increasing graduation rates and employment rates so students are able to practice as competent entry-level sonographers. An outcome goal for many sonography educational programs and sonography skills laboratory accrediting bodies alike, and anticipated to have the government eventually mandate as well with the passing of new legislation (Wilson, 2011). By changing the sonographer's role in the medical profession, which is predicted to considerably expand and include a variety of new responsibilities, while requiring sonographers to uphold the present expectations required of them (McLaughlin, 2012). Therefore, having health care reform by the government expected to influence how effective students learn and are educated in sonography.

In summary, the field of sonography is viewed as embracing and promoting, a “best practice” philosophy intended to filtrate the medical community with an optimal number of competent practicing sonographers. This research study is believed to have yielded results that assist and guide the present and future educational goals of the

sonography profession and provide applied health care educators with valid and useful information that support effective teaching practices.

CHAPTER 3

Results

As previously discussed this mixed methods study had both quantitative and qualitative dimensions and, as a consequence, some of the measures used to collect the data were designed to yield both quantitative and qualitative results. Measures which probed both dimensions were the weekly survey and the instructor scanning evaluations. Participants completed several instruments including: (1) a weekly survey (containing both quantitative and qualitative dimensions) developed for this study and, (2) a self-efficacy scale (appraisal inventory) developed for this study; utilizing Bandura's (2006) *Guide for Constructing Self-Efficacy Scales* as a reference. Additional measures yielding both quantitative and qualitative data were (3) instructor evaluations of participants scanning performance used previously in the vascular sonography laboratory course as assessment tools, and (4) the primary investigator's observations and interactions with participants. Data collection took place throughout the fall semester in a semester-long vascular sonography skills laboratory course.

Quantitative Results

Weekly survey. A 13-item weekly survey developed by the investigator was used to assess self-regulation. The quantitative data yielded by the survey included both the type and number of self-regulatory activities participants reported being involved in during the week, and the amount of practice and study time participants expended towards vascular sonography. The qualitative data from the weekly survey yielded will be described in the qualitative results section.

Self-efficacy scale. Immediately following the completion of a practice self-efficacy scale, an initial self-efficacy scale (identified to the participant as the appraisal inventory) was administered to participants. This self-efficacy scale was developed for this study, utilizing Bandura's (2006) guide as a reference. This instrument was designed to measure participants' self-reported perceived self-efficacy levels on specified sonographic skills or tasks on a rating scale from 0 to 100. A rating of zero on the scale indicated "cannot do at all", a rating of 50 indicated moderate certainty of successful performance, and a rating of 100 indicated complete certainty the skill could be completed. Participants completed this self-efficacy scale four times during the semester in weeks 1, 7, 11, 15.

Instructor evaluations of participant scanning performance. Each participant was evaluated and provided feedback on their sonographic skill performance, specifically their ability to perform sonographic examinations. These scanning evaluations were developed by the primary investigator and previously utilized for weekly assessments of participants' sonographic skill performance. Participants' sonographic knowledge and skill levels were rated in the following course objective categories of technical skill, critical thinking, professionalism/accountability, client/sonographer interaction, organization, and safety were rated as either exceeding expectations (2 points), meeting expectations (1 point), or not meeting expectations (0 points). The qualitative data the survey yielded will be described in the qualitative results section.

Findings. Quantitative findings from the weekly survey, self-efficacy scale, and instructor scanning evaluations are described in the following sections.

Weekly survey. Participants self-reported their self-regulatory activities in

weeks 3, 7, 11, and in the last week of the semester. The self-regulatory activities were organized into the following four categories: (1) completing assigned and/or additional *readings*, (2) performing required and/or voluntary *scanning*, (3) obtaining tutor and/or instructor *assistance*, and (4) viewing *example videos/images*. The primary investigator assigned scores using a 0-5 rating scale based on the number and/or type of activities participants engaged in for each of the categories.

In an initial approach to generating a composite score (hereafter referred to as Method 1), self-regulatory scores were simply summed across categories to obtain a self-regulation score for each week (i.e. weeks 3, 7, 11, and for the last week). An overall composite self-regulatory score was then calculated by summing the total self-regulatory category scores across all four weeks. This composite score was then used to sort participants into most or least self-regulated groupings.

Two alternative grouping methods were also explored as possible indices of participants' abilities to self-regulate in sonographic skill acquisition, potentially yielding more representative scores. The first of these, called here Method 2, involved the primary investigator holistically grouping participants based *solely* on her classroom observations and interactions with the students during class periods, practice sessions, and one-on-one meetings throughout the semester.

The results based on from the primary investigator's holistic judgments (Method 2) were then compared to the raw composite score grouping's results of Method 1. This comparison indicated that they were *not* closely related. For instance, some participants who had been identified as highly self-regulated by Method 2 had previously been categorized as low in self-regulation according to Method 1 (e.g. participants 2, 8, and 11

were grouped as highly self-regulated by Method 2, but low in self-regulation according to Method 1). Given the dissimilarity of the results from the two methods, a third method was considered as a basis for judging possible relationships between participants' self-regulation and level of sonographic skill acquisition.

Method 3 involved the primary investigator systematically evaluating whether each of the four self-regulatory categories (*reading, scanning, assistance, and example videos/images*) would be expected to have an equal influence on the development of sonographic skills overall. This evaluation was based on the primary investigator's long-standing teaching experience observing these self-regulatory activities in the learning of sonography students. Specifically, the primary investigator assigned weightings for each category based on her judgment of the extent to which each of these groupings of self-regulatory activities might be expected to relate to students' sonographic performance.

The weightings of each of the four categories were as follows. The first, completing assigned and/or additional *readings*, was judged to have a relatively low contribution to overall sonographic performance. For example, students who had openly admitted to not completing their reading assignments likely had done so for a multitude of reasons. One of those reasons may be instructors' routine practice of not requiring reading assignments to be submitted and a grade assigned to them. This is a different practice and requirement than for other assignments, such as sonographic scanning assignments, which are enforced and penalized if not completed as assigned. Therefore, students are observed in most cases choosing to complete those scanning assignments instead of the reading assignments. Another reason students appear to not complete the reading assignments might be due to their inability to understand their value for learning,

and having the perception they are not as helpful or a good use of their time. Although when students do not complete the reading assignments in most cases their sonographic skill performance is still identified as meeting expectations. However, meeting scanning expectations without completing the reading assignments in general is often only accomplished when students have instead engaged in other activities that are situated under one of the other self-regulatory categories. Given the researcher's judgment about reading's reduced impact on sonographic performance, this category was weighted as only 10% of the total score.

The second category, performing required and/or voluntary *scanning*, was deemed to be more closely tied to a participant's ability to acquire sonographic skill. The scoring system developed for this category provided added weight to those participants who went beyond performing scanning assignment recommendations and requirements imposed by the instructor. Performing the activities in this category, in the view of the investigator, has historically provided one of the clearest predictors of successful sonographic skill acquisition. Therefore, this grouping was weighted as 50% of the total score. Assigning half of the weight to this category was based on a judgment that in order for participants to competently learn sonography they must be engaging in the deliberate practice of the skills for it, which can only be accomplished through activities under the *scanning* category.

The third category of self-regulation was, obtaining tutor and/or instructor *assistance*. Based on the primary investigator's judgment, a slightly lower weighting was assigned to the *assistance* category based on her experience with students who were effective with sonographic skill acquisition. Likewise, based on her judgment students

who tend to acquire sonographic skills in a more efficient manner often sought the assistance of either a tutor or the course instructor during the learning process.

Furthermore, it should be noted that seeking assistance itself may reflect additional self-regulation. For instance, students seeking assistance must first schedule sessions and organize them around the somewhat limited availability of the tutor and/or instructor. Therefore, the *assistance* category was weighted as 20% of the total score.

The fourth and final category, the viewing of *example videos/images*, was also weighted less heavily by the primary researcher than the *scanning* category, once again reflecting the judged importance of the *scanning* category. However, the viewing of *example videos/images* category was determined to have an equal level of importance to the *assistance* category based on a judgment that active voluntary participation in viewing example videos and images were activities that went beyond the recommendations and requirements of the standard course work. As a result, the *example videos/images* category was weighted as 20% of the total score.

Based on these newly assigned category weightings, participants' self-regulation groupings based on Method 3 were compared to those produced by Method 1 and Method 2. In the primary investigator's judgment a more valid index of self-regulation was generated from the Method 3 than by the other two grouping methods. Method 3 therefore was utilized in subsequent self-regulation analyses to identify the participants who were the most and least self-regulated. This decision once again was based on the primary investigator's judgment and reflections about the likely influence of each category on the learning and performance of sonography students (see Table 1).

Most and least self-regulated participants and their engagement in self-regulatory activities. Based on Method 3, the three participants who were identified as being the most and least self-regulated were compared for their engagement within each of the self-regulatory activity categories: *assigned and additional readings, performing additional scanning opportunities, seeking assistance from a tutor and/or instructor, and reviewing the example videos and images of the different types of ultrasonic tasks to be performed* (see Figures 1-5).

Table 1

Participants' assignments to most and least self-regulation groups using three methods

Method 1	Method 2	Method 3
Most Self-Regulated		
Participant 5	Participant 5	Participant 5
Participant 1	Participant 11	Participant 11
Participant 7	Participant 9	Participant 9
Participant 13	Participant 2	Participant 1
Participant 9	Participant 11	Participant 4
Participant 4	Participant 8	Participant 7
Participant 6	Participant 4	Participant 13
	Participant 6	
	Participant 7	
Least Self-Regulated		
Participant 11	Participant 13	Participant 2
Participant 8	Participant 10	Participant 8
Participant 2	Participant 12	Participant 6
Participant 10	Participant 3	Participant 10
Participant 12		Participant 3
Participant 3		Participant 12

Note. In Method 1 selection of the most and least self-regulated participants was based on the raw composite score totals, which were the sum of participants' self-regulatory category scores on the four weekly surveys. In Method 2 assignment to most and least self-regulated categories was based solely on the primary investigator's holistic judgments of participants' self-regulatory performance. In Method 3 assignment was based on the sum of *weighted* self-regulatory categories, where weightings reflected the primary investigator's judgment about the influence of each of these self-regulation categories on participant sonographic performance. Method 3 was determined to yield the most accurate reflection of participants' self-regulatory levels and was used for subsequent analyses in this study.



Figure 1. Self-reported reading activity of most and least self-regulated participants across the semester. The results in Figure 1 show that the most self-regulated participants self-reported reading more than the least self-regulated participants. Also, a considerable increase in reading engagement occurred among the most self-regulated participants during the second half of the semester.

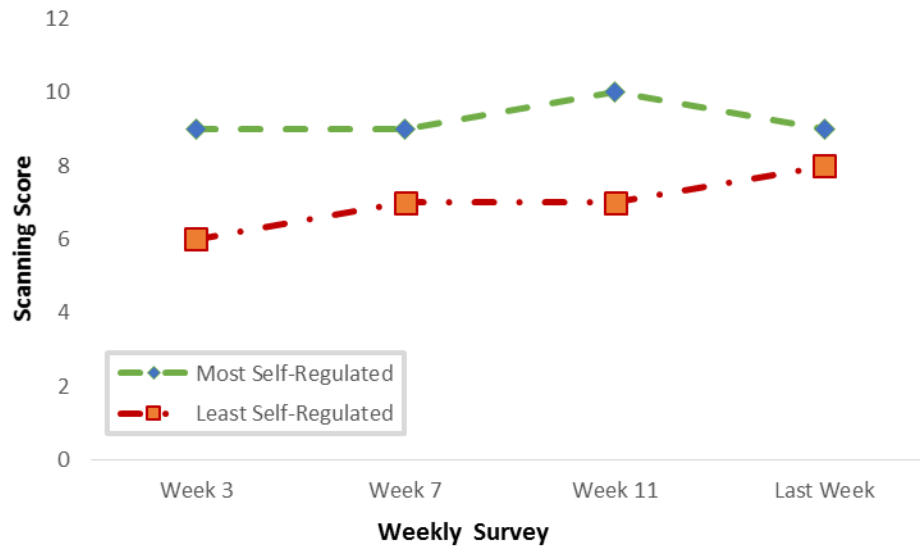


Figure 2. Self-reported scanning activity of most and least self-regulated participants across the semester. The results in Figure 2 show that the most self-regulated participants self-reported scanning throughout the semester only slightly more than the least self-regulated participants.



Figure 3. Self-reported seeking of assistance by the most and least self-regulated participants across the semester. The results in Figure 3 show that the most self-regulated participants self-reported seeking assistance throughout the semester more than the least self-regulated participants. At the beginning of the semester both groups reported obtaining assistance at higher level and declining considerably a few weeks later into the semester. However, towards the second half of the semester the most self-regulated participants reported an increased level in pursuing assistance, reaching the same level of assistance they had originally reported at the beginning of the semester. The least self-regulated participants reported the opposite, declining noticeably in their level of seeking assistance by the end of the semester.

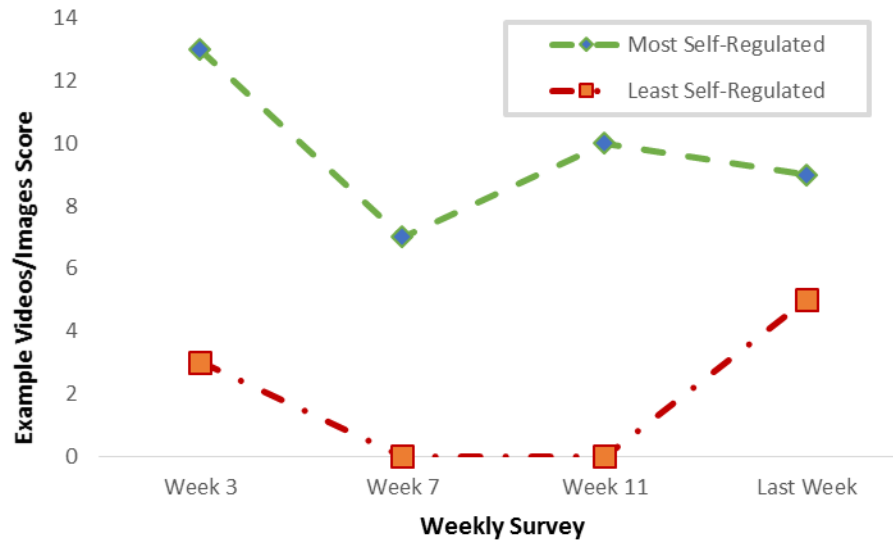


Figure 4. Self-reported viewing of example videos/images by the most and least self-regulated participants across the semester. The results in Figure 4 show that the most self-regulated participants self-reported viewing the example videos/images throughout the semester considerably more than the least self-regulated participants. As can be seen in Figure 4, a few weeks into the semester both groups reported lower mid-semester participation in this activity. It is interesting to note, that the least self-regulated group reported a considerable increase in their viewing of the example videos/images at the end of semester.



Figure 5. A comparison of most and least self-regulated participants in total self-regulated activities across the semester. The results in Figure 5 show that the most self-regulated participants self-reported having engaged in more self-regulatory activities throughout the semester than the least self-regulated participants. Both groups of participants reported a decrease in the number of self-regulatory activities they participated in a few weeks into the semester. During the second half of the semester, however, the most self-regulated participants showed a significant increase in their number of self-regulatory activities, while the least self-regulated participants did not.

Amount of time spent practicing vascular sonography. Participants were asked to self-report the amount of time they *practiced* sonographic skills on the weekly survey. The total amount of time participants reported practicing sonographic skills from a sampling of four weekly surveys (weekly survey #3, #7, #11, last week) ranged from 15.75 – 21 hours for the 13 participants with a mean of 18.69. The mean values of sonographic skill practicing for the three most and least self-regulated participants were

also calculated. The mean for the most self-regulated participants was 19 and the mean for the least self-regulated participants was 19.33.

Amount of time spent studying vascular sonography. Participants were asked on the weekly survey to self-report the amount of time they *studied* vascular sonography. The total amount of time participants reported *studying* vascular sonography from a sampling of four weekly surveys (weekly survey #3, #7, #11, last week) ranged from 15-55 hours for the 13 participants with a mean of 28.34. The mean values of studying vascular sonography for the three most and least self-regulated participants were also calculated. The mean for the most self-regulated participants was 24.66 and the mean for the least self-regulated participants was 23.16.

Self-efficacy scale. The data from the four self-efficacy scales were analyzed by first summing each of the participants' self-reported responses for each of the five sub-categories (technical skills, critical thinking, client/sonographer interaction, organization, and safety) and then calculating a total sub-category score for each self-efficacy scale. Each item on the self-efficacy scale ranged from 0-100 with every 10 units shown on the scale. A rating of zero on the scale indicated "cannot do at all", while a rating of 50 indicated moderate certainty of successful performance and, a rating of 100 indicated high certainty the skill could be completed. The summed values for each sub-category ranged from 0 to 3100 for technical skill, 0 to 800 for critical thinking, 0 to 500 for client/sonographer interaction, 0 to 500 for organization, and 0 to 600 for safety. A summed self-efficacy sub-category score was calculated by adding the five sub-category scores for each self-efficacy scale administered. Summed scores for each administration of the self-efficacy scale were graphed and tracked on each participant (see Figure 6).

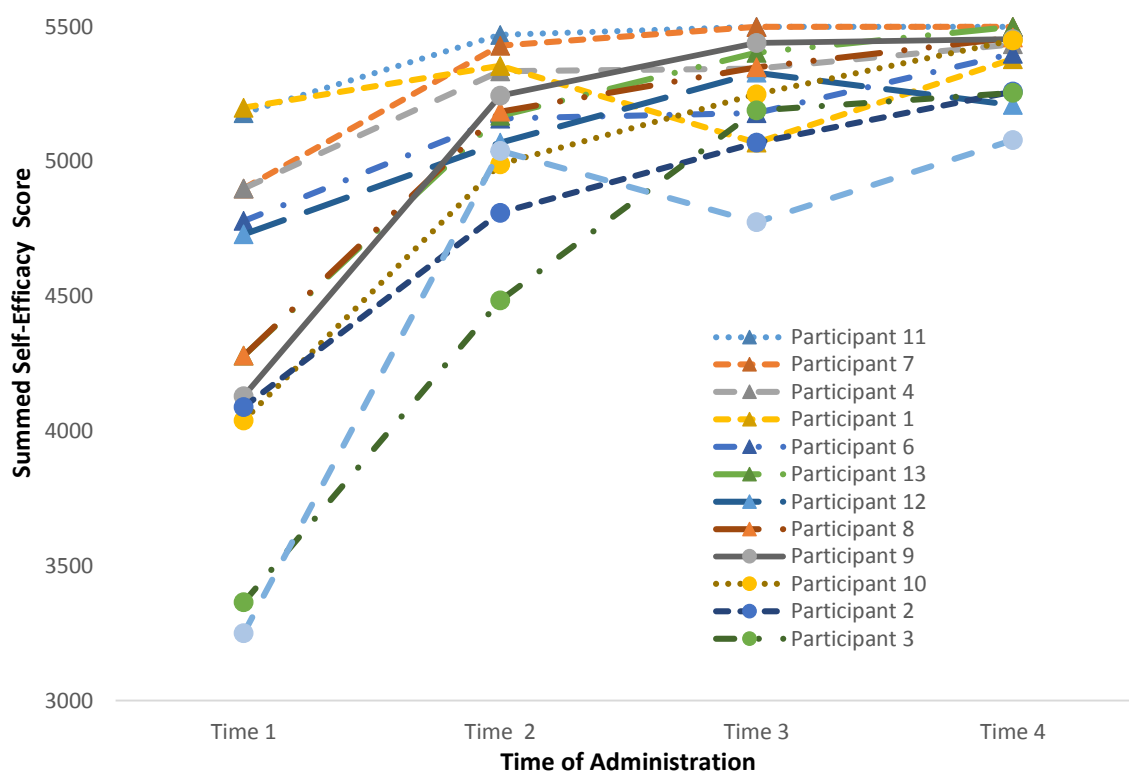


Figure 6. Summed self-efficacy scores for each participant across the semester. At the beginning of the semester participants' total self-efficacy scores showed a considerable amount of variability. As the semester progressed, however, self-efficacy scores increased for most participants, and by the end most of their scores were relatively high.

A cumulative self-efficacy scale score for each participant was calculated by adding the summed scores of the four self-efficacy scales, with participants then grouped based on these scores as having either higher or lower self-efficacy. Those participants with cumulative scores above the median (20,340) of the total number of cumulative scores were assigned to the higher self-efficacy group (7 participants) and those with scores below the median score were assigned to the lower self-efficacy group (6 participants). The summed self-efficacy scores for the higher and lower self-efficacy

group means were tracked across the four times the self-efficacy scale was administered (see Figure 7).

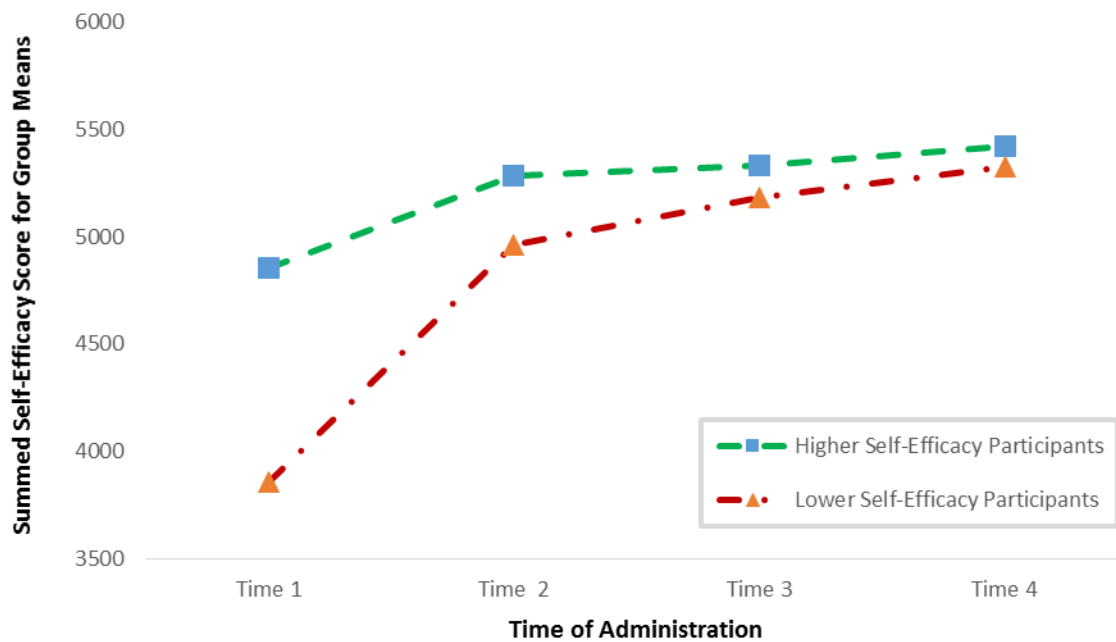


Figure 7. Trends in participants' summed self-efficacy scores across the semester based on higher and lower self-efficacy group means. The results displayed in Figure 7 show both the higher and lower self-efficacious participants reporting having a low level of self-efficacy at the initial self-efficacy scale's administration. However, for the scale's second administration there was a noticeable increase in self-efficacy scores for both groups, but with the higher self-efficacious participants still reporting slightly higher scores than the lower self-efficacious participants. For the scale's last two administrations (i.e. second half of the semester) scores increased and were high for both groups.

Furthermore, the primary investigator judged which participants presented with a higher cognitive ability level and those presenting with a lower level of cognitive ability

based on the interactions and observations she had with these participants throughout the semester. The summed self-efficacy scores for the higher and lower cognitive ability group means were tracked across the four times the self-efficacy scale was administered (see Figure 8). In addition to cognitive ability, the three most and least self-regulated participants' self-regulatory rankings were also compared to their summed self-efficacy scale scores for each time the self-efficacy scale was administered (see Figure 9).

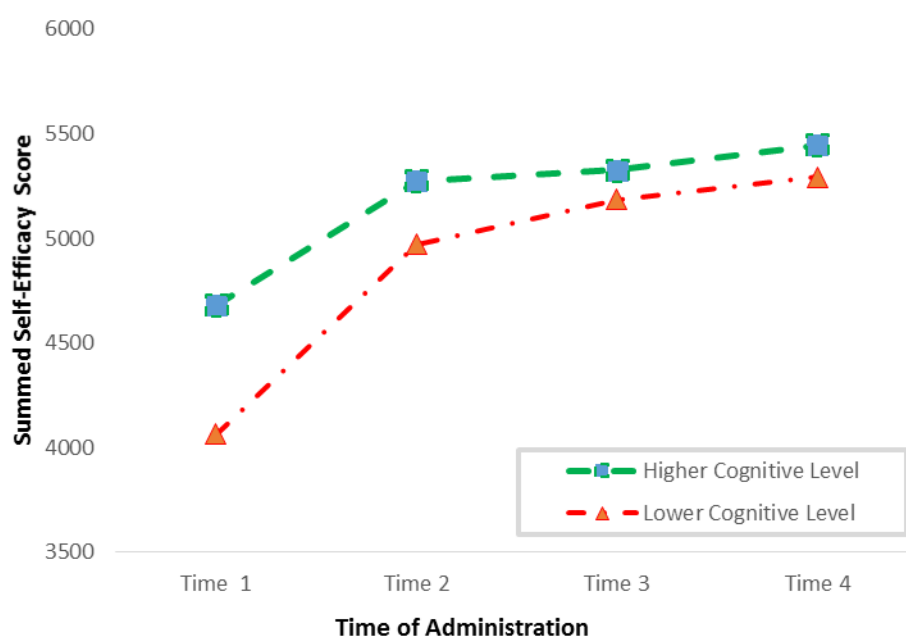


Figure 8. Trends in participants' total self-efficacy scores across the semester based on higher and lower cognitive level group means. Cognitive level was judged by the primary investigator. The results displayed in Figure 8 show that both the higher and lower cognitive participants reported having a low level of self-efficacy at the initial self-efficacy scale's administration. By the scale's second administration, however, there was a noticeable increase in self-efficacy scores for both groups with the higher cognitive participants still reporting slightly higher scores than the lower cognitive participants. For

the scale's last two administrations (i.e. second half of the semester) scores increased and were high for both groups.

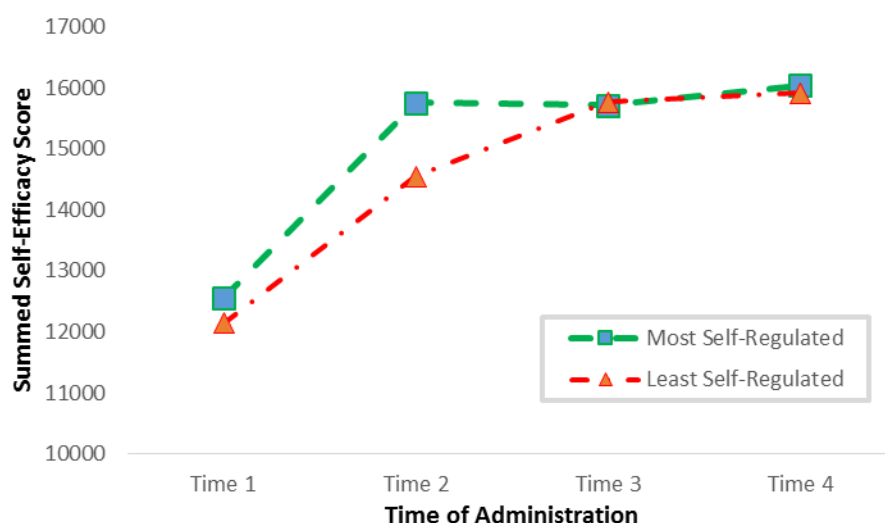


Figure 9. Changes in self-efficacy scores for the most and least self-regulated participants across the semester. The results in Figure 9 show that both the most and least self-regulated participants self-reported having a low level of self-efficacy at the initial self-efficacy scale's administration. However, for the scale's second administration there was a noticeable increase in self-efficacy scores for both groups with the most self-regulated participants still reporting slightly higher scores than the least self-regulated participants. For the scale's last two administrations (i.e. the second half of the semester) scores remained increased and became equally high for both groups.

Most and least self-efficacious participants' self-efficacy sub-category scores and summed self-efficacy sub-category scores. Each self-efficacy scale sub-category score was compared across the semester for the three highest and lowest self-efficacious participants (see Figures 10-14). The three highest and lowest self-efficacious

participants were identified through their cumulative self-efficacy ranking. Also tracked were the summed sub-category self-efficacy scores for the three highest and lowest self-efficacious participants the four times the scale was administered (see Figure 15).

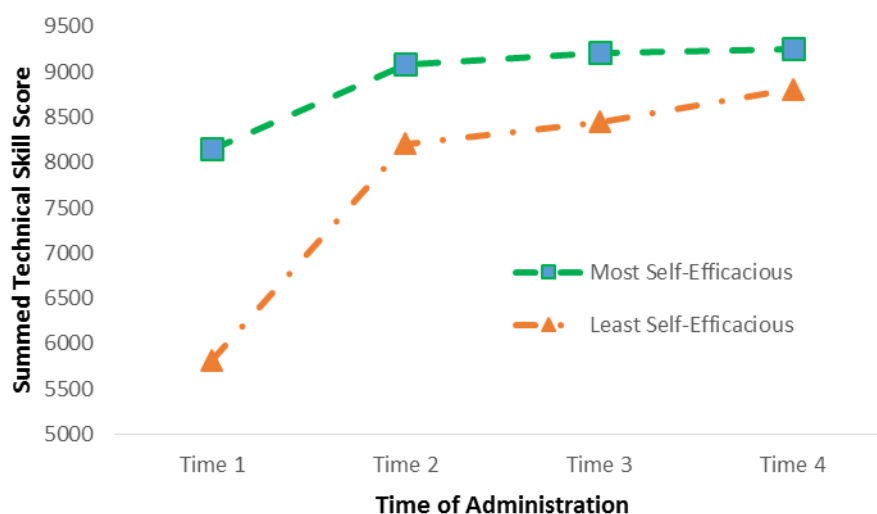


Figure 10. Technical skill self-efficacy sub-category scores for the most and least self-efficacious participants across the semester. The results displayed in Figure 10 show that both the most and least self-efficacious participants reported a low level of self-efficacy in technical skill at the initial administration of the scale. By the second administration there was a noticeable increase in self-efficacy scores for both groups with the most self-efficacious participants reporting slightly higher scores than the least self-efficacious participants. For the self-efficacy scale's last two administrations, self-efficacy technical skill scores were high for both groups.

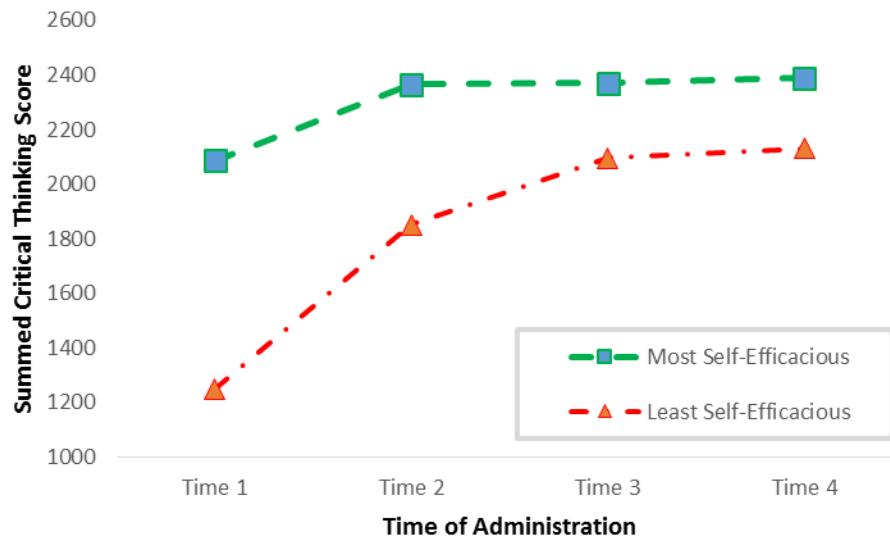


Figure 11. Critical thinking skill self-efficacy sub-category scores for the most and least self-efficacious participants across the semester. The results displayed in Figure 11 show that both the most and least self-efficacious participants reported a low level of self-efficacy in critical thinking at the initial administration of the scale. By the second administration there was a noticeable increase in self-efficacy scores for both groups with the most self-efficacious participants reporting slightly higher scores than the least self-efficacious participants. For the self-efficacy scale's last two administrations, self-efficacy critical thinking skill scores were high for both groups.

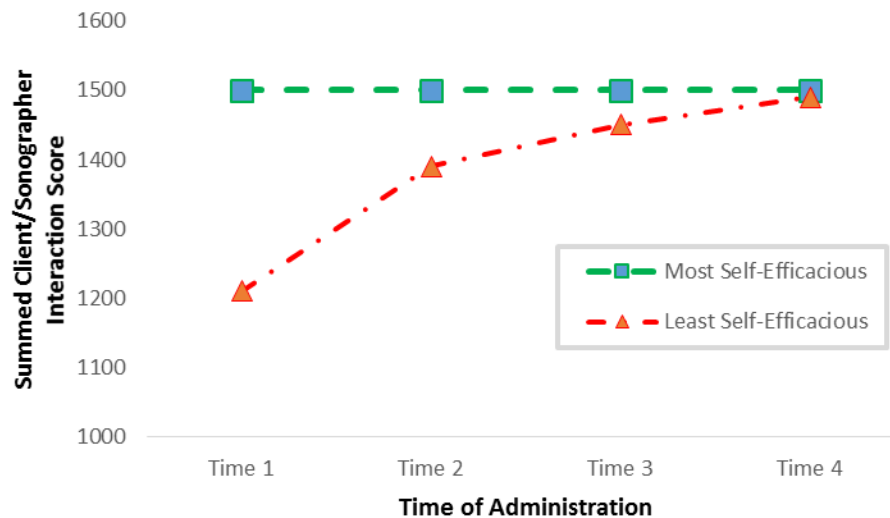


Figure 12. Client/sonographer interaction skill self-efficacy sub-category scores for the most and least self-efficacious participants across the semester. The results displayed in Figure 12 show that the most self-efficacious participants reported a high level of self-efficacy in client/sonographer interaction at the initial administration of the scale, in contrast to the least self-efficacious participants. By the scale's second administration, however, there was a noticeable increase in client/sonographer self-efficacy scores for the least self-efficacious participants, while the most self-efficacious participants maintained their high level. For the scale's last two administrations client/sonographer interaction skill scores were high for both groups.

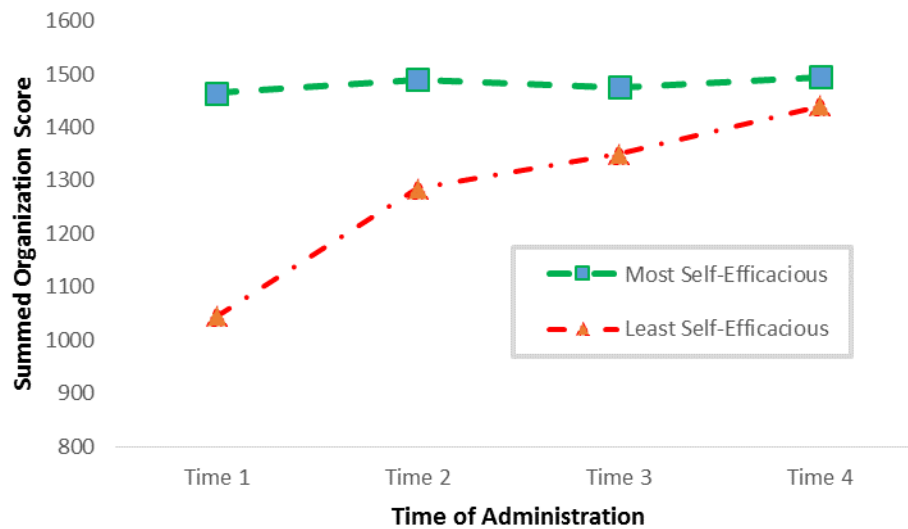


Figure 13. Organization skill self-efficacy sub-category scores for the most and least self-efficacious participants across the semester. The results displayed in Figure 13 show that the most self-efficacious participants reported a high level of self-efficacy in organization at the initial administration of the scale, in contrast to the least self-efficacious participants. By the scale's second administration, however, there was a noticeable increase in organization self-efficacy scores for the least self-efficacious participants, while the most self-efficacious participants maintained their high level. For the scale's last two administrations organization skill scores were high for both groups.

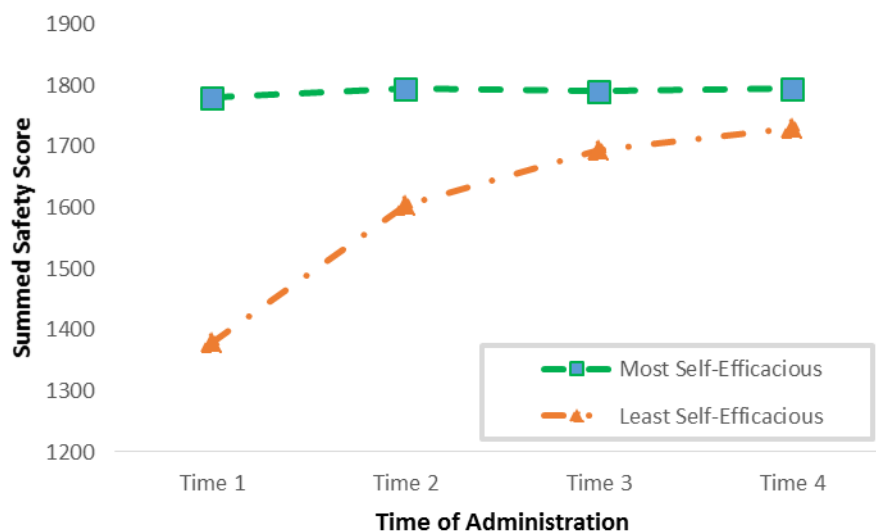


Figure 14. Safety skill self-efficacy sub-category scores for the most and least self-efficacious participants across the semester. As shown in Figures 12 and 13 for the sub-categories of client/sonographer interaction and organization, the results displayed in Figure 14 also show the most self-efficacious participants reporting a high level of self-efficacy in the use of safety practices at the initial administration of the scale, in contrast to the least self-efficacious participants. By the scale's second administration, however, there was a noticeable increase in safety self-efficacy scores for the least self-efficacious participants, while the most self-efficacious participants maintained their high level. For the scale's last two administrations safety scores were high for both groups.

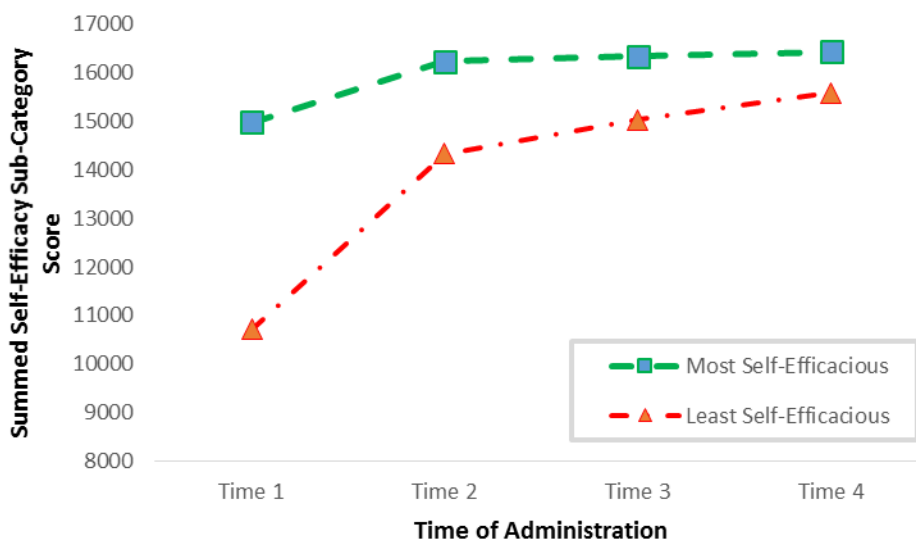


Figure 15. Summed self-efficacy sub-category scores for the most and least self-efficacious participants across the semester. The results displayed in Figure 15 show that both the most and least self-efficacious participants reported a low level of self-efficacy in overall skill at the initial administration of the scale. By the second administration there was a noticeable increase in the overall skill self-efficacy scores for both groups with the most self-efficacious participants still reporting slightly higher scores than the least self-efficacious participants. For the self-efficacy scale's last two administrations, overall skill scores were high for both groups.

Most and least self-regulated participants' self-efficacy sub-category scores and summed self-efficacy sub-category scores. Each self-efficacy scale sub-category score was compared for the three most and least self-regulated participants across the semester (see Figures 16-20). Also, tracked were the summed sub-category self-efficacy scores for the three most and least self-regulated participants the four times the scale was administered (see Figure 21).

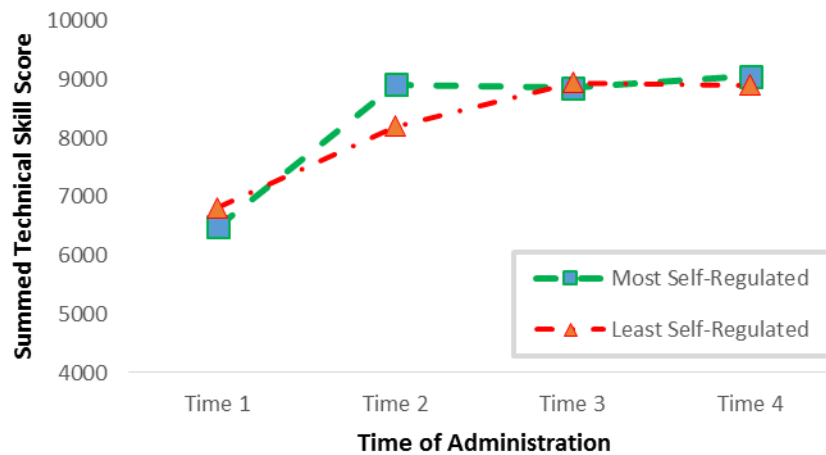


Figure 16. Technical skill self-efficacy sub-category scores across the semester for the most and least self-regulated participants. The results in Figure 16 show that both the most and least self-regulated participants reported low self-efficacy for technical skill at the initial administration of the scale. By the second administration there was a noticeable increase in self-efficacy scores for both groups with the most self-regulated participants reporting slightly higher scores than the least self-regulated participants. For the self-efficacy scale's last two administrations, self-efficacy technical skill scores were high for both groups.

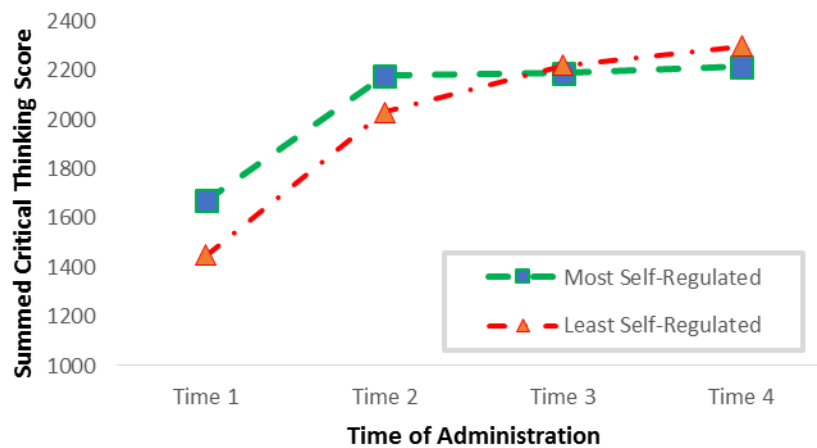


Figure 17. Critical thinking skill self-efficacy sub-category scores across the semester for the most and least self-regulated participants. The results in Figure 17 show that both the most and least self-regulated participants reported low self-efficacy for critical thinking at the initial administration of the scale. By the second administration there was a noticeable increase in self-efficacy scores for both groups with the most self-regulated participants reporting slightly higher scores than the least self-regulated participants. For the self-efficacy scale's last two administrations, critical thinking skill self-efficacy scores were high for both groups.

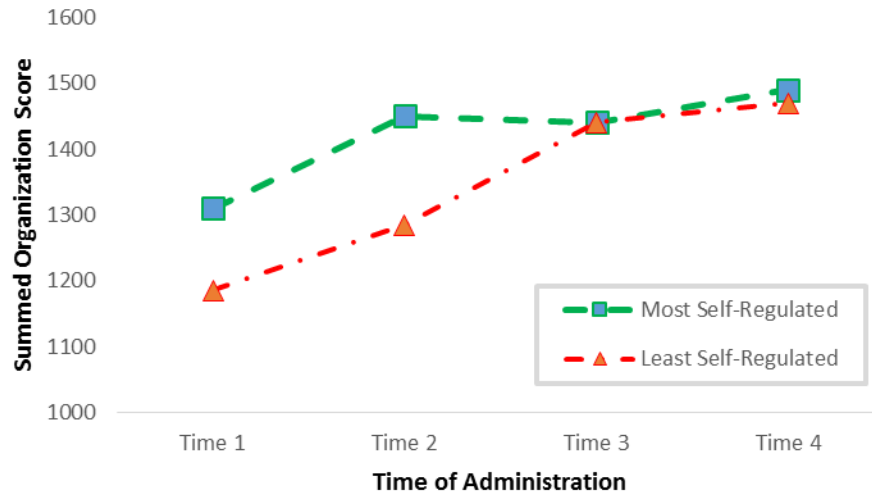


Figure 18. Organization skill self-efficacy sub-category scores for the most and least self-regulated participants across the semester. The results displayed in Figure 18 show that both the most and least self-regulated participants reported low self-efficacy for organization at the initial administration of the scale. By the second administration there was a noticeable increase in self-efficacy scores for both groups with the most self-regulated participants reporting slightly higher scores than the least self-regulated participants. For the self-efficacy scale's last two administrations, organizational skill self-efficacy scores were high for both groups.

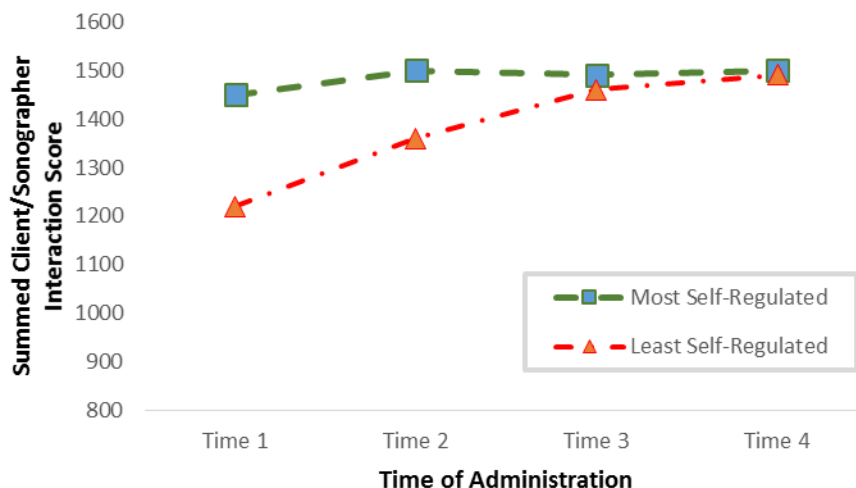


Figure 19. Client/sonographer interaction self-efficacy sub-category scores across the semester for the most and least self-regulated participants. The results displayed in Figure 19 show that the most self-regulated participants reported a high level of self-efficacy in client/sonographer interaction at the initial administration of the scale, in contrast to the least self-regulated participants. The results shown in Figure 18 show that both the most and least self-regulated participants reported low self-efficacy for organization at the initial administration of the scale. By the second administration there was a noticeable increase in self-efficacy scores for both groups with the most self-regulated participants reporting slightly higher scores than the least self-regulated participants. For the self-efficacy scale's last two administrations, client/sonographer interaction skill self-efficacy scores were high for both groups.

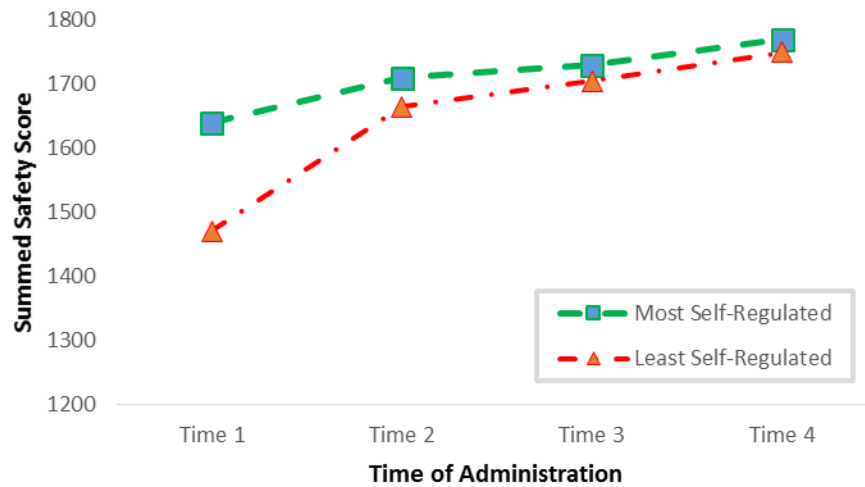


Figure 20. Safety skill self-efficacy sub-category scores for the most and least self-regulated participants across the semester. The results displayed in Figure 20 show that both the most and least self-regulated participants reported low self-efficacy for safety at the initial administration of the scale. By the second administration there was a noticeable increase in self-efficacy scores for both groups with the most self-regulated participants reporting slightly higher scores than the least self-regulated participants. For the self-efficacy scale's last two administrations, safety skill self-efficacy scores were high for both groups.

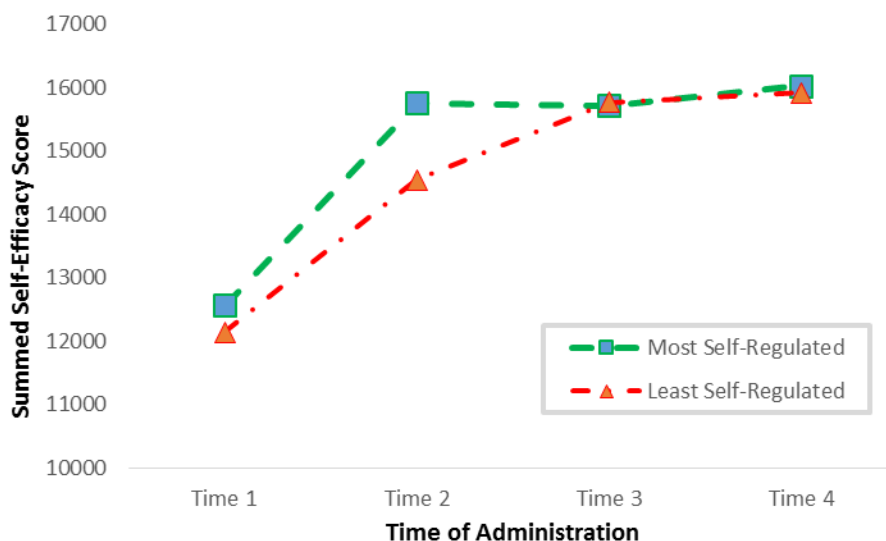


Figure 21. Summed self-efficacy scores for the most and least self-regulated participants across the semester. The results displayed in Figure 21 show that both the most and least self-regulated participants determined by Method 3 reported a low total self-efficacy score at the initial administration of the scale. By the second administration there was a noticeable increase in self-efficacy scores for both groups with the most self-regulated participants reporting slightly higher scores than the least self-regulated participants. For the self-efficacy scale's last two administrations, total self-efficacy scores were high for both groups.

Instructor evaluations of participants scanning performance. Participants' sonographic knowledge and skill levels were rated as either exceeding (2 points), meeting (1 point), or not meeting (0 points) expectations in each of the following course objective categories: technical skill, critical thinking, professionalism/accountability, client/sonographer interaction, organization, and safety. The technical skill scores for participants ranged from 13-18 points with a mean of 14.15, their critical thinking scores for participants ranged from 12-17 points with a mean of 13.92, their professionalism/accountability

scores ranged from 13-19 with a mean of 14.53, their client/sonographer interaction scores ranged from 14-17 with a mean of 14.30, their organization scores ranged from 11-18 with a mean of 13.46, and their safety scores ranged from 14-17 with a mean of 14.23. Finally, the means for the three most and least self-regulated participants for all categories summed together were also calculated. These means were 90.66 for the most self-regulated participants and 80.00 for the least self-regulated participants.

Qualitative Results

Weekly survey. In addition to its purpose of gathering quantitative data, the survey also included open and close-ended questions providing qualitative data focusing on the participants' self-regulatory activities. Participants were asked to report about the amount of practice and study time they expended towards vascular sonography, such as reasons why they believed the amount of practice and study time indicated was insufficient, self-set weekly goals, and a progress report on previously set goals. Sample qualitative survey questions included: "Please provide explanations as to why you chose the activities that you engaged in for the week" and "Do you feel the amount of time you spent practicing to scan vascular sonography this week was an adequate amount of time?"

Evaluations of participant scanning performance. Each participant was evaluated on their sonographic skill performance, specifically their ability to perform sonographic examinations. These scanning evaluations were developed by the primary investigator and regularly used for weekly assessments of participants' performance in the sonography skills laboratory. Participants' sonographic knowledge and skill levels in the following course objective categories of technical skill, critical thinking,

professionalism/accountability, client/sonographer interaction, organization, and safety were rated as either exceeding expectations, meeting expectations, or not meeting expectations. Also included on these evaluations was the primary investigator's feedback about participants' sonographic skill performance obtained by reviewing participants' recorded and live sonographic examination performances.

Primary investigator's observations and interactions with participants. The primary investigator holistically observed and interacted with the participants during class periods, practice sessions, and one-on-one meetings throughout the semester. Memoing and notetaking were utilized to record these observations and interactions of participants.

Qualitative analytic procedures for weekly survey. Analysis of this study's qualitative data began with data exploration, an early step in the data analysis process (Creswell & Plano Clark, 2011). Exploration of the data began with the primary investigator reviewing the open-ended responses on the weekly survey several times to develop a general understanding of the database (as suggested by Creswell & Plano Clark, 2011). Also as recommended by Creswell (2014) open-ended responses were then re-read and significant statements describing the participants' explanations were noted by the primary investigator. These initial statements about the participants' responses were then developed into 15 codes for the first open-ended response to the request "Please provide explanations as to why you chose the activities that you engaged in for the week? Please specify the activity and provide an explanation for it".

These codes included: (1) to have a better understanding, (2) to see what is expected, (3) to increase or improve skill level, (4) to seek extra help, (5) to learn

necessary information, (6) to practice, (7) to recall or have better recall, (8) to compare, (9) wanting instant feedback, (10) making sure on the right track, (11) memorizing protocol for time limitations, (12) meeting with the instructor helping the most, (13) always finding the readings helpful, (14) becoming a better sonographer, and (15) improving upon skill level.

Next, the primary investigator discussed her initial reactions and potential codes for representing key participant statements with a peer debriefer, a process Creswell recommended for enhancing the accuracy of intent for participants' responses. This person reviewed features of the qualitative study and asked questions of the primary investigator so that the research would resonate with people other than the investigator herself. After responses and codes were discussed, they were combined into five overarching themes.

The codes "to have a better understanding" and "recall" were grouped into the first theme: *clarification of information/skill/technique*. The codes "to learn the necessary information", "always finding the readings helpful", and "to practice" were identified as the second theme: *preparation for class or skill performance*. The codes "to improve upon skill level", "memorizing protocol for time limits", and "to be a better sonographer" were grouped as the third theme: *improvement of skill level*, while the codes "to seek extra help" and "meeting with instructor helping the most" were associated with the fourth theme: *assistance*. The final codes of "comparison", "wanting instant feedback", and "making sure on the right track" were grouped as the theme: *validation*.

Findings. The qualitative data gathered in this study provided support for and expanded the findings from the quantitative phase. Data from the six weekly open-ended survey questions were reviewed in conjunction with those from the close-ended response weekly survey questions. Responses from both types of questions were analyzed and themes identified for the first open-ended question “Please provide explanations as to why you chose the activities that you engaged in for the week?”

Explanations for activities chosen. The first open-ended weekly survey question, which was designed to provide a more detailed description of novices’ experiences while learning sonography, was “Please provide explanations as to why you chose the activities you engaged in for the week?”. Five overarching themes emerged from the data for this question: (1) *clarification of information/skill/technique*, (2) *preparation for class or skill performance*, (3) *improvement of skill level*, (4) *assistance*, and (5) *validation*.

Theme 1: Clarification of information/skill/technique. The open-ended responses to the question asking participants to provide explanations about why they chose the activities they did generated a number of responses that primarily focused on *clarification*. One phrase appearing in the responses of many participants this question was “to have a better understanding”. One of the participants explained her reasoning for engaging in the self-regulatory activities she selected was that “...all of these help with understanding the anatomy that we’re supposed to learn and scan.” Another participant stated she engaged in certain self-regulatory activities to help her “...understand the new abdominal/aorta scanning assignments this week better.”

Theme 2: Preparation for class or skill performance (at a minimum or advanced level). A second theme emerging from the open-ended responses was related to

preparation, with responses indicating participants were engaging in self-regulatory activities to help them prepare for class and/or skill performance. One participant responded by saying "...the video and images help me mentally prep for skills lab." Another participant noted he or she "...tried to get as much practice as possible for our lab quiz."

Further review of the responses pertaining to preparation suggested two reasons for why participants engaged in self-regulatory activities. The first was to prepare at a minimum to be able to accomplish the tasks that were assigned, while a second was to complete self-regulatory activities to perform at a level above and beyond minimum course expectations as judged by the primary investigator.

Theme 3: Improvement. The third theme in the open-ended responses focused on *improvement*, illustrated by one participant stating simply that their reason for engaging in self-regulatory activities was "to improve my skills." A second participant said "...to be a better sonographer," while a third responded "...to get better at taking carotid images."

Theme 4: Assistance. A fourth theme identified as *assistance* also appeared in the open-ended responses. Support for this theme came from responses indicating that participants were seeking help or extra help from either a tutor and/or instructor. Examples of responses related to this theme were "...had a tutor/lab supervisor help during a scan" and "...meeting with the instructor helped the most."

Theme 5: Validation. The final theme appearing in participants' open-ended responses to the query about reasons why they chosen the activities they did was identified as *validation*. Responses focusing on comparison of knowledge and skill level,

and requesting feedback were all categorized under this theme. One participant indicated her reason for completing the activities was "...wanting communication and instant feedback on how my scanning assignment was going." A second participant added that she "wanted to look at the images online again in order to better see what is expected. It helped me to see what I was looking for," while a third participant said, "Readings are always helpful, I like to look at the example images to compare with mine."

Amount of time spent practicing. The next survey question was "Do you feel the amount of time you spent practicing to scan vascular sonography this week was an adequate amount of time?" A majority of the participants responding to this close-ended question said "yes", but for some of the weeks a small percentage replied "no". This general question was followed by a pair of open-ended questions: "If not, why do you feel the amount of time was not adequate?" and "What kinds of things prevented you from engaging in an amount of practice scanning time that you feel would be adequate?" Some of the participants' responses to these questions indicated time constraints as a barrier to practicing scanning. These constraints seemed mainly related to an array of distractions participants experienced that interfered with their ability to practice scanning. For example, one participant stated: "I feel I should have taken more time to better my color images. Time crunches were an issue." Other participants' responses simply were observations that the amount of time they did practice was not sufficient. One participant said "I had enough time, I just still don't feel confident with these scans."

Amount of time spent studying. The next survey question was "Do you feel the amount of time you spent studying this week was an adequate amount of time?" the majority of the participants responded "yes:" however, a small percentage of the

participants indicated “no”. The open-ended questions that followed was “If not, why do you feel the amount of time was not adequate? What kinds of things prevented you from engaging in an amount of study time that you feel would be adequate?” Results showed participants had difficulty with ineffective study strategies, and that an inadequate amount of time was not a primary concern for them. For example, one participant said “I just feel like there are some subjects I should have focused more on.” Another participant stated “the test went over things that I didn’t look over closely enough.”

Identify additional goals based on instructor feedback. In response to the survey question “After reviewing the objectives and instructor feedback, do you have any goals that were not identified in the weekly objectives?” just over half of the participants early in the semester said they did have additional goals. However, as the semester progressed the number of participants who indicated having additional goals decreased dramatically with only two participants reporting having additional goals towards the end of the semester. The open-ended question that followed was “If yes, please list all goals that you have.” Overall, the responses to this survey item indicated participants in fact did have specific and detailed goals for improvement of their knowledge about sonography and their skill development. For instance, one participant stated their goal was to “stay on top of readings, keep working on scanning skills (opening up vessels, specifically the mid and distal ICA).” Another participant wrote, “I just want to continue improving on my technical skills while using color and long-axis.” It was also noted that a majority of the goals participants listed were related to decreasing the time required to perform sonographic examinations. For instance, one participant reported that their time spent conducting an examination was “...always something I strive to cut down on. So this is a

constant goal.” Participants were also asked the following “If you had goals for last week how effective were you at meeting your goals?” Their responses generally that they were able to identify either partial or full goal attainment, with a majority expressing optimism about achieving their goals. For example, one participant stated “I was very effective. My time went down for this scan and my images were much better, I thought.”

Quiz/final test-out preparation. The final item on the weekly survey asked participants to “Please discuss your quiz/final test-out preparation.” This item was an open-ended response, which showed participants utilized a variety of methods and strategies to prepare for quiz/final test-outs (e.g. studying previously learned material, generating new study materials, engaging in additional study techniques, practicing technical skills, and memorizing the protocol).

Qualitative analytic procedures for instructor evaluations of participants’ scanning performance. The data analysis process for the instructor evaluations of participants’ scanning performance was similar to that of the weekly survey. As recommended by Creswell (2014), data analysis began with the researcher reviewing the written instructor feedback of the four weekly scanning evaluations from weeks 3, 7, 11, and the last week of the semester several times. Feedback on each participant was read in its entirety to insure overall understanding by the primary investigator, and then re-read and interpreted. Next, the primary investigator discussed her initial interpretations with a peer debriefer. After this discussion, the primary investigator revised her interpretations as needed based on the peer debriefer’s recommendations (e.g., to further condense and present the interpretation of the instructor feedback in a manner that answers the research questions more completely). These feedback interpretations as judged by the primary

investigator were grouped into eight types of feedback descriptions. These feedback descriptions were then reviewed for accuracy based on the primary investigator's interpretations of the feedback with a second peer debriefer, a sonography educator who had provided similar feedback to her students. Based on this feedback from the second peer debriefer, the researcher judged that they could be condensed and concluded that six feedback descriptions (themes) would best represent the types of feedback provided to the participants.

Findings. The six different themes reflected in the feedback about participants' sonographic skill acquisition were as follows:

Theme 1: Feedback was positive, detailed, and indicated demonstration of skills.

Theme 2: Feedback was neutral, detailed, and indicated demonstration of skills.

Theme 3: Feedback was positive, detailed, but indicated that the skill was *almost not* demonstrated and instruction was needed on major activities and concepts.

Theme 4: Feedback was positive, detailed, but indicated that skill was *almost not* demonstrated and instruction was needed on major activities and concepts, and that assistance was offered.

Theme 5: Feedback was positive, detailed, but indicated that skill was *not* demonstrated and instruction was needed on major activities and concepts, and that *no* assistance was offered.

Theme 6: Feedback was positive, but indicated skill was *not* demonstrated and instruction was needed on major activities and concepts, and that assistance was offered.

Based on the primary investigator's interpretation of the weekly scanning evaluation feedback, those participants who were identified as the least self-regulated by Method 3 had a higher incidence of *not* or *almost not* demonstrating skill in performing the major activities/concepts of scanning assignments and of needing further instruction with them and details compared to the most self-regulated participants (see Table 2).

Qualitative analytic procedures for primary investigator's observations and interactions with participants. Data from the primary investigator's observations and interactions with participants were analyzed by her first reading through memos and notes generated by observing them inside of the skills laboratory and in one-on-one meetings with them. After reading and re-reading these records, the primary investigator reflected then on their performance levels and overall feedback she had provided to them throughout the entire semester. Based on this analysis, the primary investigator made a judgment of participants' cognitive ability and grouped them according to it. In the view of the primary investigator, this analysis was validated through the extended amount of time she spent with these participants over an entire semester, her multiple interactions with them, and her extensive experience teaching and evaluating students.

Findings related to primary investigator's observations and interactions with participants. Seven participants were judged by the primary investigator as having high cognitive ability and six having low cognitive ability for sonography. These participant groupings were then compared to the most and least self-regulated participants based on Method 3. The most self-regulated participants were participants 5, 11, 9, 1, 4, 7, and 13. Out of these seven participants, five were judged to have high cognitive ability. The participants judged to have high cognitive ability and also to be the most self-regulated

were participants 11, 4, 1, 13, and 9. The least self-regulated participants were participants 2, 8, 6, 10, 3, and 12. Of these six, four were judged to have low cognitive ability. The participants who were identified as having both low cognitive ability and being the least self-regulated were participants 7, 12, 10, 2, 3, and 5.

Table 2

Feedback themes on scanning evaluations for the most and least self-regulated participants

Participant	Selected Scanning Evaluations			
	Week 3	Week 7	Week 11	Last Week
Feedback Themes: Most Self-Regulated				
Participant 5*	1	5	1	1
Participant 11*	1	1	1	1
Participant 9*	1	1	1	1
Participant 1	1	1	1	1
Participant 4	1	1	1	1
Participant 7	6	6	1	2
Participant 13	1	5	1	1
Feedback Themes: Least Self-Regulated				
Participant 2	1	1	1	1
Participant 8	1	5	1	1
Participant 6	1	1	1	1
Participant 10**	1	4	1	1
Participant 3**	1	5	1	3
Participant 12**	1	3	1	2

Note. Theme 1: Feedback was positive, detailed, and indicated demonstration of skills. Theme 2: Feedback was neutral, detailed, and indicated demonstration of skills. Theme 3: Feedback was positive, detailed, but indicated that the skill was *almost not* demonstrated and instruction was needed on major activities and concepts. Theme 4: Feedback was positive, detailed, but indicated that skill was *almost not* demonstrated and instruction was needed on major activities and concepts, and that assistance was offered. Theme 5: Feedback was positive, detailed, but indicated that skill was *not* demonstrated and instruction was needed on major activities and concepts, and that *no* assistance was offered. Theme 6: Feedback was positive, but indicated skill was *not* demonstrated and instruction was needed on major activities and concepts, and that assistance was offered.
Note: *Most Self-Regulated **Least Self-Regulated

CHAPTER 4

Discussion

The convergent parallel mixed methods design utilized in the present study allowed for both answering research questions and completing hypothesis testing in a single study. The results of this study introduce new findings on the cognitive and motivational factors linked to self-regulation (Schunk & Zimmerman, 1997) and self-efficacy (Bandura, 1986) as they relate to sonography students' abilities to learn how to perform sonographic examinations. Students who are beginning to learn how to perform sonographic examinations appear to experience both cognitive and motivational factors related to self-regulation and self-efficacy, which can affect their performance in either a positive or negative manner across a semester long skills laboratory course while learning a novel complex cognitive-motor task.

Cognitive and Motivational Factors

Self-Regulation

Among the most prominent influences identified in the present study on students' abilities to learn sonography were the type and frequency of self-regulatory activities they engaged in throughout the semester. These findings were evident in both the quantitative and qualitative data, but particularly so in the qualitative data which provided a detailed representation of sonography students' self-regulatory practices. Five overarching themes related to why participants engaged in self-regulatory activities emerged from the qualitative data. These reasons were: (1) *clarification of information/skill/technique*, (2) *preparation for class or skill performance*, (3) *improvement of skill level*, (4) *assistance*, and (5) *validation*.

Self-regulatory activities participants self-reported were compared between the most and least self-regulated participants as identified by Method 3 (see p.105). The self-regulatory activities showing the greatest difference between the two groups of participants were the amount of required and/or additional reading completed, the frequency for which instructor and/or tutor assistance was sought, and the amount of time spent viewing example videos/images, with the most self-regulated participants engaging in these self-regulatory activities more than the least self-regulated participants.

Reasons posited for this difference between the two groups of participants included the following. First, it may be that the least self-regulated participants reported reading less than the most self-regulated participants as a result of experiencing time constraints limiting their ability to engage in this activity. Specifically, time constraints were the most frequently reported reason for why participants did not engage in other self-regulatory activities (e.g., practicing, on the open-ended questions from the weekly survey) and likely could have manifested itself with this self-regulatory activity as well. That is, the least self-regulated participants may have instead focused their limited amount of time on other activities or required assignments they believed were more valuable or needed to be completed out of necessity. One other reason believed to have contributed to the least self-regulated participants reading less than the most self-regulated participants may have been their perception of not identifying reading as valuable for learning. Interestingly, several of the open-ended responses did include statements that reading was indeed helpful to their learning. However, these types of positive views of the value of reading were found to have been generally made by the more highly self-regulated participants.

The second self-regulatory activity showing a considerable difference between the most and least self-regulated participants was their levels of seeking instructor and/or tutor assistance. Specifically, the most self-regulated participants reported seeking assistance twice as much as the least self-regulated participants. This sizeable increase by the most self-regulated participants seeking more assistance was apparent toward the end of the semester. While no direct evidence on why this might be so is available in the present study, the higher levels of assistance sought by the most self-regulated participants may be tied to greater insight into the challenges of sonographic examinations. This explanation is congruent with the results of other research such as that of Berkhout et al. (2015) and Sandars and Patel (2015), both of whom have described students' self-regulation challenges in the clinical environment. Sandars and Patel, for instance, recommended addressing the difficulty associated with self-regulated learning by assisting students in developing the self-regulatory skill required to perform the diagnostic task.

A second possible reason for why the most self-regulated participants reported seeking assistance more than the least self-regulated participants may have come from their holding the view that obtaining assistance either from the instructor or tutor would assist them more than other self-regulatory activities. Interestingly, seeking assistance was also identified in the qualitative data as an activity participants reported to be a valuable part of their sonographic skill acquisition.

The last self-regulatory activity showing a noticeable difference between the most and least self-regulated participants was the viewing of example videos/images. Interestingly, although the most self-regulated participants reported on average seeking

assistance more than the least self-regulated participants, towards the end of the semester the most self-regulated participants had decreased their engagement in this activity, while the least self-regulated participants dramatically increased their viewing of example videos/images. These results differ of course from those for seeking assistance, which increased near semester's end for the most self-regulated participants, but decreased for the least self-regulated participants.

Regarding the contrast differences between most and least self-regulated individuals in seeking assistance and viewing of videos/images, both self-regulatory activities may once again be based on the time constraints on participants as they had been for the activities of practicing and reading. Potential reasons for why the least self-regulated participants engaged in the viewing of example videos/images more than seeking assistance from an instructor or tutor particularly toward the end of the semester could have been the ease at which engaging in this self-regulatory activity was for them. Due to its increased accessibility to view the videos/images on their own and in settings where they have unlimited access to them. Unlike the requirements for seeking assistance, which involve the student to coordinate meetings with the instructor and/or tutor.

A second potential reason for why the least self-regulated participants tended to view the example videos/images more towards the end of the semester may have been due to them being more useful and helpful than other self-regulatory activities, a factor that participants had reported on the weekly survey as prompting them to view example videos/images. Consequently, for whichever reason why the least self-regulated participants viewed the example videos/images more, there is evidence suggesting the

least self-regulated participants realized a possible benefit for this self-regulatory activity, hence its engagement in it. Specifically, participants may have realized that they needed assistance with their sonographic skill acquisition and decided this activity could be of potential benefit to them, given that seeking instructor and/or tutor assistance was not seen as a viable option.

Although the present findings generally showed considerable difference between the most and least self-regulated participants in engaging in the aforementioned self-regulatory activities, one self-regulatory activity-deliberate practice did not. Specifically, results showed no difference in the number of hours the two groups practiced; therefore, may not be as great of an influential factor on self-regulation as others. Other findings of the present study, however, point to positive effects of deliberate practice on another variable-participant self-efficacy for performing sonographic examinations. We now turn to these results.

Self-Efficacy in Sonography

Factors appearing to affect student self-efficacy for learning sonography in a positive direction included the following were (1) using a scaffolding approach for instruction, (2) engaging in deliberate practice, (3) providing instructor and/or tutor feedback, (4) completing self-evaluations, and (5) setting goals. At the beginning of the semester participants' overall self-efficacy scores showed a considerable amount of variability. As the semester progressed, self-efficacy scores increased for most participants, and remained relatively high. It was originally hypothesized that students' self-efficacy levels would fluctuate as they progressed with their psychomotor skills training and procedural knowledge development in sonography due to the added

difficulty of learning simultaneously multiple sonographic skills. Remarkably, the largest change in self-efficacy levels occurred between the scale's first and second administrations with both groups beginning with lower self-efficacy levels on the first administration and showing a considerable increase in their levels for the second. The lower self-efficacy levels that both groups experienced at the beginning of the semester may be due to these participants all lacking prior training with sonography and it being inherently complex.

Although a majority of participants began the semester with lower self-efficacy, all of them reported being more self-efficacious after having only a few weeks of training, and maintained these higher levels of self-efficacy throughout the remainder of the semester. In this researcher's judgment, the substantial increase in self-efficacy levels observed early in the semester likely can be attributed to the manner in which sonography students are trained, which is through a *scaffolding* approach (van Merriënboer, et al. 2003). The scaffolding approach's primary purpose is to decrease the amount of cognitive load that can arise when individuals are learning to execute a complex task (Kalyuga, Chandler, & Sweller, 1998). Such, is the case with sonography. As described in detail in the introductory chapter of this dissertation, sonography requires a tremendous amount of knowledge and multiple skills that allow individuals to perform complex tasks that are both cognitive and motor in nature. As a result, learning how to perform sonographic examinations is not simple. It generates high levels of cognitive load and can interfere with ability to process information effectively. For this reason, the curricula taught in the sonography skills laboratory courses have been methodically planned to accommodate the high cognitive load demands of learning complex tasks. For

instance, a scaffolding approach is widely used to teach sonography, thereby; assisting students with skill development and improving their self-efficacy for performing these skills competently (i.e. higher self-efficacy).

In the judgment of this researcher, one of the key factors increasing student self-efficacy levels early on was the considerable amount of sonographic skills practice they engaged in. This ranged from 15.75 to 21 hours on a sampling of four weekly surveys for all 13 participants, and had an overall mean of 18.69 hours. When the mean value for all participants was compared to the mean values for the most and least self-regulated participants, these showed, that all participants engaged in roughly an equal amount of practice, resulting in high self-efficacy scores overall.

One key function of student practice is that they were able to coordinate, automatize, and proceduralize their skills and apply them in the performance of sonographic tasks. The result is that they were able to improve upon their skills as well as their perception that they were becoming more capable of performing these skills competently; both likely sources of self-efficacy.

Another factor judged to have had a positive effect on self-efficacy levels was the individualized feedback that participants received about their sonographic skill performance. This feedback was paired on a consistent basis with their self-assessments of how they performed the sonographic skills. Taken together, this feedback and participants' self-evaluations are judged not only to enhance students' actual sonographic skills, but also their perceptions of themselves as competent, two factors that have been theorized by Bandura (1986) and Aper et al. (2012) to influence self-efficacy levels.

These results suggest that when sonography students are trained with Bandura's principles as described previously in research literature, are provided with regular written and/or oral instructor/tutor feedback, and who complete self-evaluations on their sonographic skill and performance, higher self-efficacy levels are likely to positively influence skill acquisition. This was stated as an early hypothesis for the current research study and appears to have been confirmed by the findings of this study and other prior research.

For instance, Bosse et al. (2015) compared effects of high and low frequency expert feedback for first and second year medical students in the early stages of learning clinical procedural skills. Like Bosse et al. the present research study also investigated feedback's effect for when novices are learning clinical procedural skills. Bosse et al.'s findings suggested high frequency expert feedback is important for procedural skill development. Consistent with those findings, the results of the present study show feedback to play a prominent role in sonography students' attainment of their procedural knowledge and skills.

These findings related to feedback is further supported by the six different feedback themes that emerged from the qualitative data. Specifically, the feedback being delivered the most to participants was judged to be positive, detailed, and focused on demonstration of skills, with findings indicating that those students receiving this type of feedback were both successful in skill development and at performing the required sonographic examinations adequately.

Similar to Bosse et al. (2015) and the present study, Wittler et al. (2016) also studied feedback in skill acquisition. Again, their findings showed faculty review and

feedback are effective in enhancing skill acquisition and self-assessment accuracy, both desired outcomes for the present study.

A final factor expected to have increase self-efficacy levels was goal-setting. In the current study, sonography students' goal-setting ability was assessed across a semester-long skills laboratory course in which they engaged in self-regulatory activities and, received extensive feedback as they practiced their sonographic skills. Findings showed more than half of the participants said they developed additional goals early in the semester. As the semester progressed, however, the number of participants who indicated having additional goals decreased dramatically with only two participants reporting additional goals towards the end of the semester. Interestingly, this decrease in goal-setting occurred when task difficulty increased and self-efficacy levels remained high. This suggests that giving sonographic students detailed and frequent feedback as part of deliberate practice and having them, engage in frequent self-evaluations of their sonographic skills may offset the need for setting goals later, and perhaps hinting at a view that goal-setting may be less influential than feedback, deliberate practice, and self-evaluation.

Overall, a majority of students in the current study maintained their higher self-efficacy levels throughout most of the semester-long course. However, three of the thirteen participants reported a decrease in their self-efficacy levels after the scale's second administration. Two participants indicated lower levels of self-efficacy at the third administration and one participant did so at the fourth and final administration. Closer examination of the study's results for these participants with lower self-efficacy levels, revealed that the participant reporting a decrease in their self-efficacy level at the

scale's last administration had two lower scanning evaluation grades prior to administration of the scale. This was also the case for one of the two participants with lower self-efficacy scores on the scale's third administration, who had a lower scanning evaluation grade the week prior to administration. For the other participant showing a decrease in self-efficacy, it was noted that this participant had informed the primary investigator about their lack of confidence in performing the sonographic examinations being learned and practiced at that time (see Chemers et al., 2011), suggesting that previous performance influences self-efficacy levels and should be considered when evaluating student skill performance.

In sum, findings from the present study and prior research on self-efficacy conducted in other domains (e.g., Locke & Latham, 2006) showed that students' self-efficacy levels do fluctuate while learning novel complex tasks, including learning to perform sonography. More importantly, the extent to which self-efficacy levels were found to have changed appear to be related to the amount of feedback that individuals receive and their engagement in self-evaluation. This study also demonstrates that considerable increases in self-efficacy levels may result from individuals receiving feedback and performing self-evaluations within a scaffolding approach to instruction.

Additionally, based on the present findings and from prior research, self-efficacy can be influenced by factors beyond feedback and self-efficacy, most particularly deliberate practice. On the other hand, although self-efficacy has been shown to function as a strong predictor for motivated and self-regulated behaviors (Bandura, 1997), in the present study self-efficacy was not a robust predictor for identifying those individuals who were more or less self-regulated. The present study's findings also were in contrast

to Locke and Latham's (2002) research that suggested students who are more self-regulated tend to have higher levels of self-efficacy (Locke & Latham, 2002).

Finally, it should be noted that the present study's classification of the most and least self-regulated participants based on Method 3 did *not* closely align with their self-efficacy scale scores. For example, two of the three most self-regulated participants initially were among of the lowest in self-efficacy, and one of the three least self-regulated participants began with one of the highest self-efficacy scores, suggesting that the predictive properties of self-efficacy alone may not be sufficient as originally theorized when learning novel complex cognitive-motoric tasks. That is, such tasks may be more complex and require other factors in addition to self-efficacy to predict self-regulation and motivation accurately.

Although self-regulation rankings for the participants identified as most and least self-regulated did not differ greatly from those derived from their self-efficacy scores, there was a substantial difference between these two groups in their overall instructor scanning evaluation scores based on their demonstration of sonographic knowledge and skills. The means for the three most and least self-regulated participants were 90.66 for the most self-regulated participants and 80.00 for the least self-regulated participants, suggesting that the level of an individual's self-regulation may in fact influence their scanning performance.

Membership in cognitive ability groupings also was estimated based on students' use of self-regulation strategies in scanning performance. This comparison showed that of the seven participants who had been identified as the most self-regulated, five also were judged to also have high cognitive ability. In contrast, of the six participants who

had been identified as the least self-regulated, four were judged to have low cognitive ability, strongly suggesting that an individual's level of self-regulation may be tied to their levels of cognitive ability.

Limitations of Current Research

Among the limitations of the current research are the following. First, information about students' self-regulatory practices and their self-efficacy levels was primarily gathered from self-reports, which has the potential for biasing both the actual degree to which students self-regulated and their self-efficacy levels. It should be noted, however, that the primary investigator made her holistic judgments about students' abilities to self-regulate based on her many years as a teacher and her interactions with these particular students during class periods, practice sessions, and one-on-one meetings throughout the semester.

Also, the method the researcher utilized for judging students' self-regulatory levels was a product of several levels of evaluation, which were then finally formalized and used to develop Method 3, which was used in the final analyses for the data on self-regulation. Also, when the quantitative data for self-regulation and self-efficacy were analyzed, they were evaluated for their congruence with the students' self-reported data and the themes emerging from students' responses on open-ended questions.

Another potential limitation for the current study was the dual roles that the primary investigator played, which included both her roles as also being the research participants' instructor. Having the primary investigator as the participants' instructor as well could have biased the responses and data students reported on the weekly survey and the self-efficacy scale. However, to minimize the potential adverse effects of the primary

investigator holding two roles in the research study, all participants were informed that the results would not be reviewed and analyzed until their grades were submitted for the course that they were enrolled in during the research study.

Additional limitations relate to the sample and procedure. The sample included only 13 participants, of whom most 11 were female. The study was conducted in a skills laboratory course that had no more than a 6:1 student to faculty ratio in a CAAHEP accredited program. Therefore, the results of the study may not be generalizable to everyone who learns sonography and to courses that are not a skills laboratory course or for courses with larger class sizes.

The final limitation identified for this study was related to the instructor evaluations of participants' scanning performance for course purposes. These evaluations were made using a mastery scale to rate participants' sonographic skill performance on weekly skills laboratory assignments. Participants' sonographic skill performance was rated in six course objective categories as either exceeding, meeting, or not meeting expectations. However, this initial type of grading scale was found not to produce adequate variability in participants' sonographic skill performance, with many students evaluated as having met expectations each week. Therefore, when these data were initially analyzed, much of it did not produce useful information. A different assessment tool that is more aimed at evaluating students' sonographic skill performance as they are developing their knowledge and skills would be more useful than mastery measure.

Recommendations for Educators

Based on the findings from the current study, recommendations are directed to those educators who teach novices conceptual knowledge and skills needed to perform complex cognitive-motoric tasks. They are highly encouraged to instruct their students using a scaffolding approach in order to decrease the amount of cognitive load that learning how to perform complex tasks can entail. An additional recommendation is to focus on the learning process itself. One dimension of this focus should be to have students engage in deliberate practice of all skills required to perform the medical assessment. A second point of focus should be for educators to provide frequent and detailed feedback about their students' knowledge and skill performance as soon as students begin practicing and learning those skills. This feedback can be either in an oral and/or written form. Coupled with the feedback should be self-evaluations by students of their own knowledge and skill levels. Additionally, it is recommended that, beginning early on in the course, educators meet with their students on a regular basis to review and discuss with them their conceptual and skill development.

This researcher also would recommend that medical educators periodically monitor their students' self-efficacy levels during the learning process. More importantly, however, they should take steps to build student self-efficacy as early as possible and implement strategies to maintain these levels. Attempting to increase self-efficacy levels, permitting interventions to be initiated that can assist in raising their levels of self-efficacy before it negatively affects their sonographic skill acquisition and performance. Raising self-efficacy levels can be accomplished by having students

participate in deliberate practice accompanied by self-evaluation and detailed instructor feedback about their performance.

A final recommendation for educators is to make available a variety of self-regulatory activities to their students. Specifically, students should be encouraged to regularly: (1) completing all assigned and/or additional *readings*, (2) obtain regular tutor and/or instructor *assistance*, and (3) view *example videos/images* for students to view on their own in settings where they have unlimited access to them.

Suggestions for Future Research

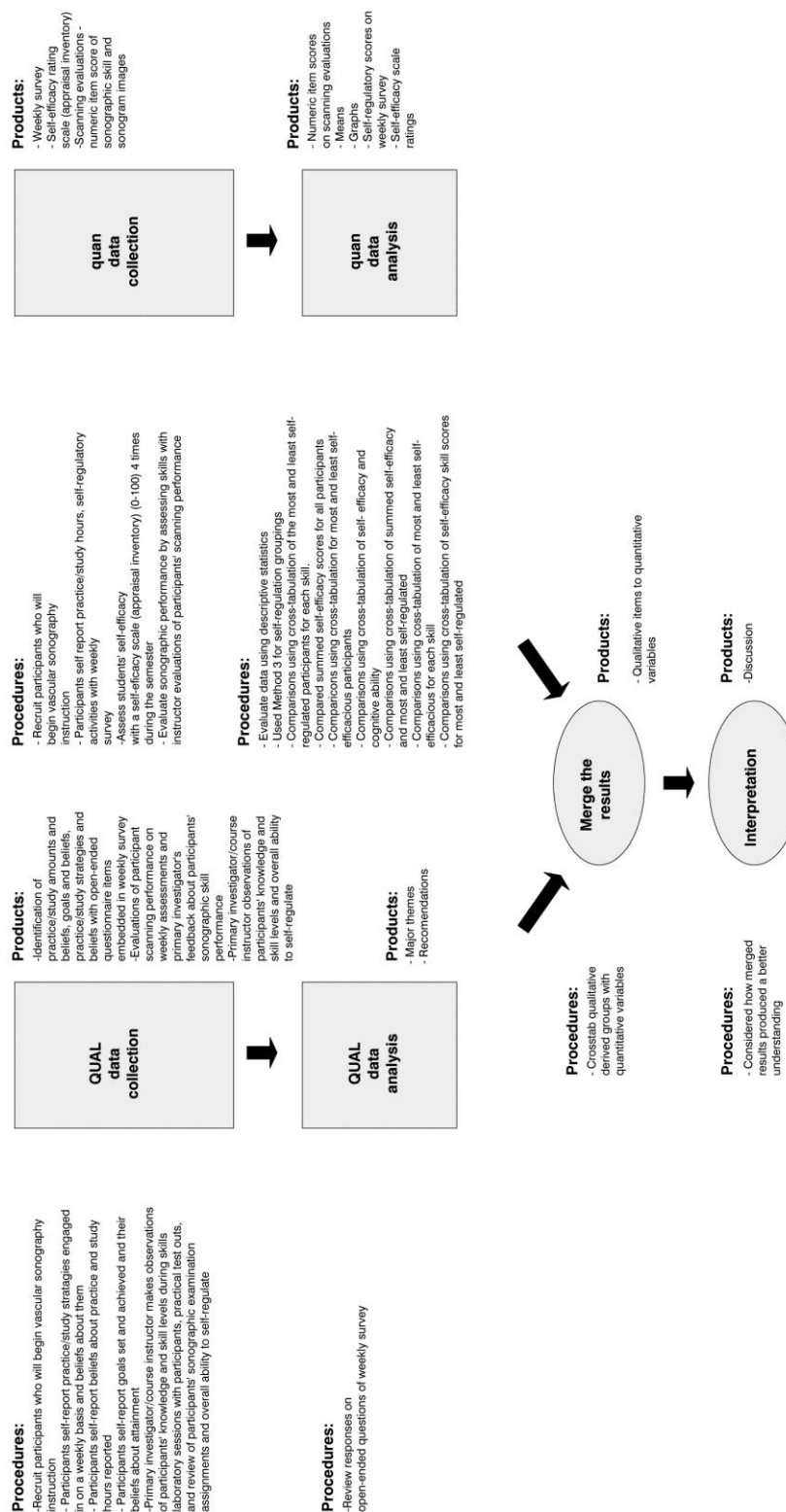
Future research suggested by the present study include the following. First, future research needs to identify and explore strategies that will motivate less self-regulated students to engage in the self-regulatory activities that more successful students use. In addition, research is needed to identify the specific reasons for why and when more self-regulated students engage in particular self-regulatory activities. Also recommended is research aimed at identifying the amount/duration of the self-regulatory activities students need to produce the most effective skill and conceptual growth and that yield improved performance overall.

Based on challenges encountered in the present study, research is needed to develop and test assessment tools that more adequately reliably and validly evaluate students' sonographic skill and performance levels. Further research also is needed linking student self-regulatory behaviors and self-efficacy to instructional characteristics and instructor behaviors. For example, research focused on identification of self-regulatory activities that are the most effective for skill acquisition can also evaluate their value for increasing self-efficacy.

Finally, both the qualitative and quantitative dimensions of this research study gave a more complete understanding of the cognitive and motivational factors that students encounter in learning sonography and how the motivational constructs of self-regulation and self-efficacy affect students' abilities to learn and perform. The results from this study are anticipated to have both educational and clinical implications by providing sonography educators with research-based methods for helping their students learn to perform complex cognitive-motoric tasks more rapidly and competently, first during the process of skill development and later as highly informed and skillful sonographers.

Appendix A

Visual Design Diagram



Appendix B

Script for Recruiting Research Participants

My name is Christy Horn and I am a professor of Educational Psychology at the University of Nebraska. I am here today because I am interested in students' experiences when learning to be a sonographer. We know learning to perform sonographic examinations is not an easy task. We also are aware of the fact that people are different and have different learning strategies. A goal of this study is to explore how different learning strategies can benefit students. I am conducting a study in which you will be asked to complete the following items, all of which are also a part of routine assigned course work: regularly assigned weekly sonographic examinations, three assigned practical test-out quizzes during the semester, assigned practical final test-outs towards the end of the semester. In addition to the regularly assigned course work there will be weekly online surveys and approximately four appraisal inventories throughout the semester. Completion of and responses made on the surveys and appraisal inventories will be anonymous until final grades have been given. You are eligible to participate because you are a sonography student enrolled in the Vascular Sonography Skills I course at the college you are attending. You must be 19 years old or older to participate. Your decision to participate or not to participate will not negatively affect your course grade.

As sonography students you will obtain 5 volunteer hours for the time you are actively participating in the study that would count towards the volunteer hour graduation requirement at the college you are enrolled in for the sonography courses. There are a number of other ways that you can receive volunteer hours such as volunteering to serve a meal at the local soup kitchen, participating in College recruitment events (e.g. Sonography night, All College Visit Day), and other various community events where volunteers are needed. You may ask any questions concerning this research and have those questions answered before agreeing to participate in or during the study. You may contact Renee Hathaway, the primary principal investigator at any time by email (renee.hathaway@bryanhealth.org) or phone, (402) 481-8561, or Dr. Christy Horn, the secondary principal investigator at any time by either email (chorn1@unl.edu) or phone, (402) 472-8404.

Participation in this study is voluntary. You may refuse to participate or withdraw at any time without harming your relationship with the researchers, Bryan College of Health Sciences, or Bryan Health or in any other way receive a penalty or loss of benefits to which you are otherwise entitled.

Appendix C

Informed Consent Form for Scanning Participants

INFORMED CONSENT FORM

Identification of Project: Exploring the relationship among self-efficacy, goal-setting, and self-regulation and their effect on student academic performance while students learn and perform complex skill sets through a mixed methods approach

Purpose of the Research:

You are invited to participate in a research study entitled “The Relationship among Self-Efficacy, Goal-Setting, and Self-Regulation and Their Effect on Student Academic Performance: A Mixed Methods Study”. The following information is provided to help you make an informed decision whether or not to participate. If you have questions at any time, please do not hesitate to ask.

You are eligible to participate because you are a Vascular Sonography student enrolled in Vascular Sonography Skills I at Bryan College of Health Sciences. You must be 19 years old or older to participate. The purpose of the study is to explore the motivational constructs of self-efficacy, goal-setting, and self-regulation along with their relationship to students’ academic performance who are in an applied health care education program while they learn complex skill sets that include both cognitive and psychomotor skills. The study will involve completing weekly sonographic examinations, weekly online surveys, and appraisal inventories during the semester. Your decision to participate or not to participate will not negatively affect your course grade.

Procedure:

Participation in this study will require approximately 5 additional hours of your time that is above the regularly required time that it will take to complete course work for Vascular Sonography Skills Lab I over the span of the semester. As a part of the research study you will complete the following items, all of which are also a part of routine assigned course work: regularly assigned weekly sonographic examinations, three assigned practical test-out quizzes during the semester, assigned practical final test-outs towards the end of the semester. In addition to the regularly assigned course work there will be weekly online surveys and approximately four appraisal inventories throughout the semester. Completion of and responses made on the online surveys and appraisal inventories will be anonymous until the completion of the course occurs.

Risks and/or Discomforts:

The only known risk for this research is a loss of privacy. Please see the confidentiality section of this consent form on how your confidentiality will be protected.

Benefits:

You may help in identifying what are some of challenges and strategies that are related to learning complex skill sets that you have while performing sonographic procedures. The information gained from this study will allow the investigators to better understand how to help individuals learning sonography or complex skill sets to become competent in a more effective manner.

Confidentiality:

Any information obtained during this study that could identify you will be kept strictly confidential. The primary and secondary investigators will be the only individuals to have access to the information completed by the participants. To maintain research subject confidentiality research participants will be assigned a code and this will be their only identifier on the weekly online surveys. The secondary investigator will assign and distribute codes to research participants for the weekly online surveys. Other research data originally recorded on paper while

research participants are engaging in the research will be also coded and saved to a secured hard drive and the hard copy destroyed after the investigators transfer it to a digital format. The information obtained might be published in scientific journals or presented at scientific meetings, but the data will be presented with code identifiers.

Compensation:

Vascular Sonography students will obtain 5 volunteer hours for the time they are actively participating in the study that would count towards the volunteer hour graduation requirement.

Opportunity to Ask Questions:

You may ask any questions concerning this research and have those questions answered before agreeing to participate in or during the study. You may contact Renee Hathaway, the primary principal investigator at any time by email (renee.hathaway@bryanhealth.org) or phone, (402) 481-8561, or Dr. Christy Horn, the secondary principal investigator at any time by either email (chorn1@unl.edu) or phone, (402) 472-8404. Please contact the investigator if you want to voice concerns or complaints about the research.

Please contact the Bryan College of Health Sciences Institutional Review Board at (402) 481-3967 or University of Nebraska-Lincoln Institutional Review Board at (402) 472-6965 for the following reasons:

- you wish to talk to someone other than the research staff to obtain answers to questions about your rights as a research participant
- to voice concerns or complaints about the research
- to provide input concerning the research process
- in the event the primary investigator could not be reached,

Freedom to Withdraw:

Participation in this study is voluntary. You can refuse to participate or withdraw at any time without harming your relationship with the researchers, Bryan College of Health Sciences, or Bryan Health or in any other way receive a penalty or loss of benefits to which you are otherwise entitled.

Consent, Right to Receive a Copy:

You are voluntarily making a decision whether or not to participate in this research study. Your signature certifies that you have decided to participate having read and understood the information presented. You will be given a copy of this consent form to keep.

Signature of Participant:

Signature of Research Participant

Date

Name and Phone number of investigator(s)

Renee B. Hathaway, Principal Investigator
Christy A. Horn, Secondary Principal Investigator

Office: (402) 481-8561
Office: (402) 472-8404

Appendix D

Practice Self-Efficacy (Appraisal Inventory) Instrument

Practice Appraisal Inventory

* 1. Please enter your assigned participant code here.

To familiarize yourself with the rating form, please complete this practice item first.

If you were asked to lift objects of different weights right now, how certain are you that you can lift each of the weights described below?

Rate your degree of confidence by recording a number from 0 to 100 using the scale given below:

0	10	20	30	40	50	60	70	80	90	100
Cannot do at all			Moderately can do					Highly certain can do		

* 2. Lift a 10 pound object.

Confidence (0-100)

Have you lifted this weight in the
past? (Y/N)

* 3. Lift a 20 pound object.

Confidence (0-100)

Have you lifted this weight in the
past? (Y/N)

* 4. Lift a 50 pound object.

Confidence (0-100)

Have you lifted this weight in the
past? (Y/N)

* 5. Lift a 80 pound object.

Confidence (0-100)

Have you lifted this weight in the
past? (Y/N)

* 6. Lift a 100 pound object.

Confidence (0-100)

Have you lifted this weight in the
past? (Y/N)

* 7. Lift a 150 pound object.

Confidence (0-100)

Have you lifted this weight in the past? (Y/N)

* 8. Lift a 200 pound object.

Confidence (0-100)

Have you lifted this weight in the past? (Y/N)

* 9. Lift a 300 pound object.

Confidence (0-100)

Have you lifted this weight in the past? (Y/N)

Appendix E

Self-Efficacy to Perform Sonographic Examinations (Carotid Duplex Examination)

Appraisal Inventory #1

Introduction and Technical skill

* 1. Please enter your assigned participant code here.

This questionnaire is designed to help us get a better understanding of the kinds of things that are difficult for students. Please rate how certain you are that you can do each of the things described below by writing the appropriate number. Your answers will be kept strictly confidential and will not be identified by name.

Rate your degree of confidence by recording a number from 0 to 100 using the scale given below:

0	10	20	30	40	50	60	70	80	90	100
Cannot do at all					Moderately can do					Highly certain can do

If you were asked to perform the tasks listed below right now, how certain are you that you can perform each of the tasks described below?

* 2. Select and use properly the correct equipment to support completing study (e.g. blood pressure cuff, stethoscope, CW Doppler)

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 3. Select appropriate transducer

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 4. Select appropriate preset

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 5. Enter patient/examination information correctly

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 6. Acquire sonographic images as indicated

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 7. Select appropriate depth for area being scanned

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 8. Adjust TGC and Gain controls correctly

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 9. Select and set appropriate number and position of focal zones

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 10. Adjust color steering to provide accurate data

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 11. Adjust color gain to provide accurate data

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 12. Adjust color box size and position to provide accurate data

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 13. Adjust Doppler angle and position to provide accurate data

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 14. Adjust spectral scale/baseline to provide accurate data

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 15. Adjust spectral gain to provide accurate data

Confidence (0-100)

Course work/Training of skill
(Y/N)

Appraisal Inventory #1

Obtain optimal ultrasonic images of anatomy

Rate your degree of confidence by recording a number from 0 to 100 using the scale given below:

0	10	20	30	40	50	60	70	80	90	100
Cannot do at all				Moderately can do				Highly certain can do		

If you were asked to perform the tasks listed below right now, how certain are you that you can perform each of the tasks described below?

Obtain optimal ultrasonic images of anatomy:

* 16. Rt. Common Carotid Artery (CCA)

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 17. Lt. Common Carotid Artery (CCA)

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 18. Rt. Internal Jugular Vein (IJV)

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 19. Innominate Artery

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 20. Rt. Subclavian Artery

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 21. Lt. Subclavian Artery

Confidence (0-100)

Course work/Training of skill
(Y/N)

*** 22. Thyroid gland**

Confidence (0-100)

Course work/Training of skill
(Y/N)*** 23. Trachea**

Confidence (0-100)

Course work/Training of skill
(Y/N)*** 24. Sternocleidomastoid muscle (SCM)**

Confidence (0-100)

Course work/Training of skill
(Y/N)*** 25. Rt. Bulb**

Confidence (0-100)

Course work/Training of skill
(Y/N)*** 26. Lt. Bulb**

Confidence (0-100)

Course work/Training of skill
(Y/N)*** 27. Rt. Internal carotid artery (ICA)**

Confidence (0-100)

Course work/Training of skill
(Y/N)*** 28. Lt. Internal carotid artery (ICA)**

Confidence (0-100)

Course work/Training of skill
(Y/N)*** 29. Rt. External carotid artery (ECA)**

Confidence (0-100)

Course work/Training of skill
(Y/N)*** 30. Lt. External carotid artery (ECA)**

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 31. Rt. Vertebral artery

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 32. Lt. Vertebral artery

Confidence (0-100)

Course work/Training of skill
(Y/N)

Appraisal Inventory #1

Critical Thinking

Rate your degree of confidence by recording a number from 0 to 100 using the scale given below:

0	10	20	30	40	50	60	70	80	90	100
Cannot do at all			Moderately can do					Highly certain can do		

If you were asked to perform the tasks listed below right now, how certain are you that you can perform each of the tasks described below?

* 33. Recognize anatomy when displayed on the screen or body

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 34. Recognize the significance of color and the directions of flow

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 35. Obtain and record appropriate and pertinent medical history prior to beginning the examination

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 36. Apply didactic (e.g. lecture) information to skill lab sessions

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 37. Apply previously acquired skills lab knowledge to new situations

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 38. Select and utilize appropriate patient/transducer positions to adequately visualize the peripheral vasculature

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 39. Recognize and evaluate normal findings

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 40. Recognize conditions that may contraindicate the examination

Confidence (0-100)

Course work/Training of skill
(Y/N)

Appraisal Inventory #1

Patient/Sonographer Interaction

Rate your degree of confidence by recording a number from 0 to 100 using the scale given below:

0	10	20	30	40	50	60	70	80	90	100
Cannot do at all					Moderately can do					Highly certain can do

If you were asked to perform the tasks listed below right now, how certain are you that you can perform each of the tasks described below?

* 41. Introduces self to patient as a vascular sonography student
and the study/its purpose

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 42. Explains examination with guidance at an appropriate communication level to
the patient

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 43. Provide for the patient's personal and environmental
comfort

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 44. Recognize changes in patient's comfort level and make
adjustments accordingly

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 45. Use AIDET correctly

Confidence (0-100)

Course work/Training of skill
(Y/N)

Appraisal Inventory #1

Organization

Rate your degree of confidence by recording a number from 0 to 100 using the scale given below:

0	10	20	30	40	50	60	70	80	90	100
Cannot do at all					Moderately can do					Highly certain can do

If you were asked to perform the tasks listed below right now, how certain are you that you can perform each of the tasks described below?

*** 46. Gather necessary supplies before procedure**

Confidence (0-100)

Course work/Training of skill
(Y/N)

*** 47. Make the proper adjustments to the ultrasonic machine, bed, and patient for the most optimal scanning experience**

Confidence (0-100)

Course work/Training of skill
(Y/N)

*** 48. Follow examination protocol assigned for each procedure in the correct manner**

Confidence (0-100)

Course work/Training of skill
(Y/N)

*** 49. Perform the examinations in a reasonable time frame to commensurate with the level of education and experience**

Confidence (0-100)

Course work/Training of skill
(Y/N)

*** 50. Complete paperwork correctly**

Confidence (0-100)

Course work/Training of skill
(Y/N)

Appraisal Inventory #1

Safety

Rate your degree of confidence by recording a number from 0 to 100 using the scale given below:

0	10	20	30	40	50	60	70	80	90	100
Cannot do at all					Moderately can do					Highly certain can do

If you were asked to perform the tasks listed below right now, how certain are you that you can perform each of the tasks described below?

* 51. Confirm patient identification and verify the examination assigned

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 52. Assist in inspection of equipment for electrical or safety hazard and damage

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 53. Utilize equipment in a manner that maintains optimal functioning
(e.g., turning on and off, cleaning, recognizing malfunctions, trouble shooting)

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 54. Implement good hand hygiene technique at appropriate time

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 55. Sanitize all equipment that comes in contact with the patient

Confidence (0-100)

Course work/Training of skill
(Y/N)

* 56. Minimize the risk of musculoskeletal injury during performing studies by using correct body and patient positioning

Confidence (0-100)

Course work/Training of skill
(Y/N)

Appendix F

Directions for When Self-Efficacy Scale is Administered

By filling out this questionnaire you will be contributing to the body of research in an important manner. The knowledge that the questionnaire will provide will increase understanding and guide the curriculum and assessment development of programs designed to teach students in applied health care fields, such as sonography.

Appendix G

Weekly Survey Items

Week #4 Online Survey

* 1. Please enter your assigned participant code here.

2. Please check any and all of the following activities that you engaged in this week.

- ☐ Sonography Machines (entering patient information) Power Point
- ☐ AIDET Video
- ☐ Assigned Readings
- ☐ Additional Readings
- ☐ Performed Additional Scans
- ☐ Received Assistance from a Tutor
- ☐ Received Assistance from an Instructor
- ☐ Carotid Video for Handout 1
- ☐ Carotid Video for Handout 2
- ☐ Carotid Video for Handout 3
- ☐ Carotid Video for Handout 4
- ☐ Carotid Study Images 1
- ☐ Carotid Study Images 2
- ☐ Carotid Study Images 3
- ☐ Carotid Study Images 4
- ☐ ABI Video
- ☐ Lower Arterial Duplex Video for Handout 5
- ☐ Lower Arterial Duplex Video for Handout 6
- ☐ Lower Arterial Duplex Video for Handout 7
- ☐ Lower Arterial Study Images 1
- ☐ Lower Arterial Study Images 2
- ☐ Lower Arterial Study Images 3
- ☐ Lower Venous Duplex Video for Handout 8
- ☐ Lower Venous Duplex Video for Handout 9
- ☐ Lower Venous Study Images 1-2
- ☐ Lower Venous Study Images 2-2
- ☐ Abdominal Video for Handout 10
- ☐ Abdominal Video for Handout 11
- ☐ Abdominal Study Images 1
- ☐ Abdominal Study Images 2

Other (please specify)

3. Please provide explanations as to why you chose the activities that you engaged in for the week? Please specify the activity and provide an explanation for it.

* 4. How much time did you practice scanning vascular sonography this week?
(answer as a number to the nearest half hour, enter 1/2 hour as .5 e.g. 3 hours and 30 minutes would be 3.5)

* 5. Do you feel the amount of time you spent practicing to scan vascular sonography this week was an adequate amount of time?

☐ Yes

☐ No

6. If not, why do you feel the amount of time was not adequate? What kinds of things prevented you from engaging in an amount of practice scanning time that you feel would be adequate?

* 7. How much time did you study vascular sonography course work this week?
(answer as a number to the nearest half hour, enter 1/2 hour as .5 e.g. 3 hours and 30 minutes would be 3.5)

* 8. Do you feel the amount of time you spent studying this week was an adequate amount of time?

☐ Yes

☐ No

9. If not, why do you feel the amount of time was not adequate? What kinds of things prevented you from engaging in the amount of study time that you feel would be adequate?

* 10. After reviewing the objectives and instructor feedback, do you have any goals that were not identified in the weekly objectives?

☐ Yes

☐ No

11. If yes, please list all goals that you have.

12. If you had goals for last week how effective were you at meeting your goals?

Please answer the following if you were preparing to take a practical quiz/final test-out.

13. Please discuss your quiz/final test-out preparation.

Appendix H

Weekly Scanning Evaluation for Carotid Duplex Examination

Time started: _____

Time ended: _____

Student Name: _____ Date: _____ Week # _____ Volunteer # _____

Study Identification (MRN #) _____ Total Time to Complete Study _____

Evaluator:

Overall Grade on Technical Skill: _____

Overall Grade on Critical Thinking: _____

Overall Grade on Professionalism/Accountability: _____

Overall Grade on Patient/Sonographer Interaction: _____

Overall Grade on Organization: _____

Overall Grade on Safety: _____

*These 6 units are recorded as separate grades, and all must Exceed or Meet expectations for a passing grade.

There may be a grade deduction if any component is absent from the study protocol or has elicited repeated comments to correct in that particular category which it is graded.

SCALE:

Exceeded or Met requirements without errors

(E) Exceeded Expectations

Met requirements with minor errors

(M) Meets Expectations

Did not meet requirements

(U) Unsatisfactory

N/A: Not applicable

Technical Skill: Grade: E M U / Comment

1. Selects and uses properly the correct equipment to support completing study (e.g blood pressure cuff, stethoscope, CW Doppler) [Grade in lab]

2. Selected appropriate transducer

3. Selected appropriate preset

4. Correctly entered patient/examination information

5. Recorded study visually as indicated

6. Recorded study audibly as indicated

7. Selected appropriate depth for area scanned

8. Set appropriate TGC and Gain

9. Selected and set appropriate number and position of focal zones

10. Adjusts color steering to provide accurate data

11. Adjusts color scale to provide accurate data
12. Adjusts color gain to provide accurate data
13. Adjusts color box size and position to provide accurate data
14. Adjusts Doppler angle and position to provide accurate data
15. Adjusts spectral scale/baseline to provide accurate data
16. Adjusts spectral gain to provide accurate data
17. Obtains optimal ultrasonic images of anatomy:
 - Rt. Common Carotid Artery (CCA) T, S, P, M, D
 - Lt. Common Carotid Artery (CCA) T, S, P, M, D
 - Rt. Internal Jugular Vein (IJV)
 - Lt. Internal Jugular Vein (IJV)
 - Innominate Artery
 - Rt. Subclavian Artery
 - Lt. Subclavian Artery
 - Thyroid gland
 - Trachea
 - Sternocleidomastoid muscle (SCM)
 - Rt. Bulb
 - Lt. Bulb
 - Rt. Internal carotid artery (ICA) T, S, P, M, D
 - Lt. Internal carotid artery (ICA) T, S, P, M, D
 - Rt. External carotid artery (ECA)T, S, P
 - Lt. External carotid artery (ECA)T, S, P
 - Rt. Vertebral artery S, P, M
 - Lt. Vertebral artery S, P, M
18. Identifies anatomy through proper annotation:
 - Rt. Common Carotid Artery (CCA) T, S, P, M, D
 - Lt. Common Carotid Artery (CCA) T, S, P, M, D
 - Rt. Internal Jugular Vein (IJV)
 - Lt. Internal Jugular Vein (IJV)
 - Innominate Artery
 - Rt. Subclavian Artery
 - Lt. Subclavian Artery
 - Thyroid gland
 - Trachea
 - Sternocleidomastoid muscle (SCM)
 - Rt. Bulb
 - Lt. Bulb
 - Rt. Internal carotid artery (ICA) T, S, P, M, D
 - Lt. Internal carotid artery (ICA) T, S, P, M, D
 - Rt. External carotid artery (ECA)T, S, P
 - Lt. External carotid artery (ECA)T, S, P
 - Rt. Vertebral artery S, P, M
 - Lt. Vertebral artery S, P, M

Critical Thinking: Grade: E M U / Comment

1. Recognizes anatomy when displayed on the screen or body
 2. Recognizes the significance of color and the directions of flow
 3. Obtained and recorded appropriate and pertinent medical history prior to beginning the study
 4. Applies didactic (e.g. lecture) information to skill lab sessions
 5. Begins to adapt previously acquired knowledge to new situations
 6. Selects and utilizes appropriate patient/transducer positions to adequately visualize the peripheral vasculature [Grade in lab]
 7. Recognizes and evaluates normal findings
 8. Begins to recognize conditions that may contraindicate the examination [Grade in lab and throughout the week]
-

Professionalism/Accountability: Grade: E M U / Comment

1. Complies with program and lab affiliate policies and procedures in regard to attendance (on-time), attire (wears clean lab coat or scrubs), hygiene, and conduct [Student grades in lab] M or U
2. Does not allow outside factors to interfere with professional responsibilities
3. Respects the right of the instructor to make decisions and suggestions about the student's skill level and the student complies with those decisions and suggestions
4. Ensures that client information and conversation are held in confidence
5. Recognizes limitations and seeks help when necessary
6. Responds to feedback in a positive manner (reads and signs instructor's critiques)
7. Incorporates guidance and feedback from the instructor into performance
8. Conducts ongoing self-assessment and self-evaluations as a means of improvement
9. Develops collaborative relationships with other Health Professions instructors and students
10. Assimilates knowledge and expertise of instructor and other health care providers as appropriate
11. Demonstrates non-discriminatory attitudes, comments, and behavior to everyone in the learning environment regardless of age, sex, illness, ethnicity, color, creed, nationality or lifestyle
12. Seeks to expand individual competency within the scope of safe practice
13. Attends assigned skill lab hours without unexcused absence or tardiness [Student grades in lab] M or U
14. Demonstrates competency with new and previous acquired skills

15. Completes lab assignments, critiques, and competencies on time and according to guidelines
16. Submits a completed signed consent form on each client

Patient/Sonographer Interaction: Grade: E M U / Comment

1. Introduces self to patients as a vascular sonography student and the study/its purpose [Grade in lab]
2. Explains examination with guidance at an appropriate communication level to the patient [Grade in lab]
3. Uses discretion when asking questions of the patient [Grade in lab]
4. Refrains from inappropriate communication with clients and others [Grade in lab]
5. Provides for the patient's personal and environmental comfort [Grade in lab]
6. Recognizes changes in patient's comfort level and makes adjustments accordingly [Grade in lab]
7. Protects the patient's modesty [Grade in lab]
8. Begins to anticipate patient's needs and provides required assistance due to any illness or disability [Grade in lab]
9. Uses AIDET correctly [Student grades in lab] M or U

Organization: Grade: E M U / Comment

1. Gathers necessary supplies before procedure [Grade in lab]
2. Makes the proper adjustments to the ultrasonic machine, bed, and patient for the most optimal scanning experience [Grade in lab]
3. Restocks and changes linen and other supplies after each use
4. Provides the next person with a clean and orderly room
5. Follows study protocol assigned for each procedure in the correct manner
6. Performs the examinations in a reasonable time frame to commensurate with the level of education and experience
7. Paperwork is fully completed and submitted in the required orderly fashion (e.g. grammatically correct, correct spelling, written in a manner that contains appropriate content, stored under proper week and order, studies labeled)
8. Signs-up and uses the machine for an assignment during the correct amount of allotted time

Safety: Grade: E M U / Comment

1. Confirms patient identification and verifies the examination assigned (clears off patient I.D. from machine)
2. Assists in inspection of equipment for electrical or safety hazard and damage
3. Monitors and modifies the skills lab environment to prevent and cleanliness falls
4. Utilizes equipment in a manner that maintains optimal functioning

(e.g., turning on and off, cleaning, recognizing malfunctions, trouble shooting.)

5. Implements good hand hygiene technique at appropriate time [Grade in lab]
6. Sanitizes all equipment that comes in contact with the patient
7. Reports situations that may impact the safety of patient and student
8. Minimizes the risk of musculoskeletal injury during performing studies by using correct body and client positioning (also performs ergonomic exercises) [Student and Instructor grade in lab and throughout the week]
9. Wears gloves at the appropriate time
10. Implements institutional protocol for emergencies

I have read and understand the evaluator's comments.

Student Signature: _____ Date: _____

Appendix I
Skills Lab Schedule

<u>Date</u>	<u>Topic Being Learned</u>	<u>Number of Class Time Hours</u>	<u>Schedule of Research Measures Administered to Participants</u>
Week 1	Ergonomic demo/ identify carotid anatomy in transverse plane and gray scale add in subclavian artery and innominate. a.	3	-Informed Consent -Practice Appraisal Inventory (Self-Efficacy) -Actual Appraisal Inventory (Self-Efficacy) -Weekly Survey -Scanning Evaluation
Week 2	Identify carotid anatomy in transverse and sagittal planes (History + Vertebral artery + Blood Pressure)	3	-Weekly Survey -Scanning Evaluation
Week 3	Identify carotid anatomy in transverse and sagittal planes with color	3	-Weekly Survey -Scanning Evaluation
Week 4	Combine gray scale with color in transverse and sagittal planes add spectral Doppler -Carotid Duplex	3	-Weekly Survey -Scanning Evaluation
Week 5	Arterial scan of legs in gray scale transverse and sagittal planes	3	-Weekly Survey -Scanning Evaluation
Week 6	Continue arterial scan of legs and Carotid Duplex	3	-Weekly Survey -Scanning Evaluation
Week 7	Arterial scan of legs in gray scale and color in sagittal plane with ankle brachial indices (ABI's)	3	-Weekly Survey -Actual Appraisal Inventory (Self-Efficacy) -Scanning Evaluation
	Carotid Duplex Quiz-practical test out this week in front of instructor	3	-Weekly Survey -Scanning Evaluation for

Week 8	10/11 12:30-1:30 _____ 10/11 1:30-2:30 _____ 10/11 2:30-3:30 _____ 10/12 11:30-12:30 _____ 10/12 12:30-1:30 _____ 10/12 1:30-2:30 _____		Practical Test Out
Week 9	Arterial scan of legs in gray scale and color in sagittal plane with (ABI's) add spectral Doppler-Arterial Duplex	3	-Weekly Survey -Scanning Evaluation
Week 10	Venous scan of legs in gray scale transverse compressions and sagittal planes with color	3	-Weekly Survey -Scanning Evaluation
Week 11	Venous scan of legs in gray scale transverse compressions and sagittal planes in color and Doppler	3	-Weekly Survey -Scanning Evaluation -Actual Appraisal Inventory (Self-Efficacy)
Week 12	Arterial segmental testing - Carotid Duplex Scan will also be graded-Recorded-Lower Venous Duplex Quiz-practical test out this week	3	-Weekly Survey -Scanning Evaluation
Week 13	Arterial segmental testing- If not completed yet do Lower Venous Duplex Quiz-practical test out this week-Recorded	3	-Weekly Survey -Scanning Evaluation
Week 14	No Class-Thanksgiving Break		
Week 15	Abdominal-Aorta and Kidney-Recorded-Lower Arterial Seg Quiz-practical test out this week-	3	-Weekly Survey -Scanning Evaluation
Week 16	Abdominal –Aorta and Kidney-If not completed yet do Lower Arterial Seg Quiz-practical test out this week-Recorded	3	-Weekly Survey -Actual Appraisal Inventory (Self-Efficacy) -Scanning Evaluation

Week 17	Finals Week- Final-practical test outs this week 12/13 12:30-1:30 _____ 12/13 1:30-2:30 _____ 12/13 2:30-3:30 _____ 12/14 11:30-12:30 _____ 12/14 12:30-1:30 _____		-Scanning Evaluation for Practical Test Out
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